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THE EFFECTS OF

SOVIET ARMY COMMUNICATIONS JAMMING

ON THE AIM DIVISION SIGNAL BATTALION

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

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This study attempts to show that the US Army AIM division signal battalion can not provide reliable communications support when confronted with the current Soviet radioelectronic combat threat. The AIM division signal battalion mission and its current radio systems are explained in detail. The doctrine, equipment, and known capabilities of the Soviet communications jamming organizations are examined.

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The Effects of Soviet Army Communications Jamming on the AIM Division Signal Battalion

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6 June 1980

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MASTER OF MILITARY ART AND SCIENCE

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ABSTRACT

THE EFFECTS OF SOVIET ARMY COMMUNICATIONS JAMMING ON THE AIM DIVISION SIGNAL BATTALION, by Major John R. Williamson, USA, 149 pages.

This study attempts to show that the U.S. Army AIM division signal battalion can not provide reliable communications support when confronted with the current Soviet radioelectronic combat threat. The investigation is centered on the fact that the division maneuver commanders are not familiar with the difficulties and complexities of the communications-electronics mission in an electronic warfare environment and currently rely too heavily on electronic communications to maintain command and control on the battlefield.

The AIM division signal battalion mission and its current radio systems are explained in detail. The doctrine, equipment, and known capabilities of the Soviet communications jamming organizations are examined. Recent computer based technical analyses of the effectiveness of the Soviet radioelectronic combat threat on division level communications is presented.

The author concludes that current AIM division signal battalions would not be able to maintain reliable command and control communications systems on the modern electronic battlefield when confronted with the full effects of the Soviet radioelectronic combat threat.

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CHAPTER I

INTRODUCTION

Signal commanders are held directly responsible for providing adequate communications-electronics support under all threat circumstances. Although aspects of electronic warfare, electro-magnetic pulse, and combat casualties are known in some detail, their total effect, either singularly or in combination, is not widely understood. Yet a signal leader and his superior commander must understand the total effect of the threat environment on their mission to succeed. Considering the current knowledge of these problems by personnel other than communications specialists, the use and survivability of U.S. Army communication systems during a modern battle could be a commander's nightmare.

Many qualified signal officer's careers have ended prematurely because of their presumed failures during command. Most of these reliefs of command could likely have been avoided by a better understanding of the difficulties and complexities of the communications-electronics mission by both the signal battalion commander and his superior. The failure of a communications system may be the result of enemy electronic warfare efforts and not the result of either equipment failure or operator error.

Detailed studies, e.g., the Integrated Tactical Communications System study (Rienzi, 1976), are conducted for the development of communications equipment. The need for new equipment is based on the present equipment's failure to accomplish current and future mission requirements. Sadly, information pertaining to equipment failure is often not readily available to the signal battalion commander and his superior. Therefore, the signal battalion commander's performance is often only judged by his superior's convictions of equipment capabilities, which may not necessarily be those commonly held throughout the communications-electronics community. Simply, the communications user is often not aware of the shortcomings of the equipment the signal battalion commander has under his command.

Available unclassified electronic warfare literature is very general in scope. The focus of the majority of electronic warfare literature is on tactical frequency modulation (FM) radio equipment used at maneuver battalion and brigade command levels. Although this information is useful to the prospective signal battalion commander on a conceptual basis, it does not provide information pertaining to the majority of the communications equipment used by the AIM division signal battalion. It is,

therefore, the purpose of this thesis is to investigate the communication jamming effects of the electronic warfare (EW) threat on a signal battalion's ability to accomplish its mission. A specific signal organization, the armor, infantry, and mechanized infantry (AIM) division signal battalion, is selected for study. This unit is utilized because of its important mission of providing tactical communications to the division and its deployment in the brigade rear and division area of operations.

Hypothesis

The Soviet Army's communications jamming capabilities will severely interfere with and impede the mission accomplishment of the AIM division signal battalion. A better understanding of the difficulties and complexities of the communications-electronics mission, when exacerabated by the communications jamming threat, by both signal officers and their commanders is needed to enhance survivability on the electronic battlefield.

Methodology

Existing literature on subjects relative to this thesis is researched to determine the Soviet Army communications jamming capabilities and AIM division signal battalion capabilities. A technical analysis of the communications

jamming threat versus the AIM division signal battalion is discussed to analyze the overall effectiveness of the threat capabilities. A specific example, a worst case, is utilized to determine maximum effects. A quantitative evaluation is then used to determine specific effects on the division command control communications (C^3) capabilities.

The majority of detailed information concerning Soviet radioelectronic combat is classified; therefore, a separate annex is required to research this topic in depth. This annex expands the technical analysis of Soviet communications jamming capabilities to interfere with and impede the AIM division signal battalion communications systems. The quantitative evaluation presented is a direct result of the 1976 Integrated Tactical Communications Systems (INTACS) study and later assessments of the findings of that study.

In order to include the most recent U.S. military doctrinal information, selected course material from the 1979-1980 U.S. Army Command and General Staff College curriculum is utilized. The ideas and opinions of the resident instructors and guest speakers were considered as valid emerging doctrine when such information was found to be widely supported throughout the college. This was considered necessary because of the dynamic nature of military doctrine.

Assumptions and Limitations

The potential impact of the Soviet Army's communications jamming capabilities on the AIM division signal battalion is a very complex problem. A complete investigation of all aspects of this problem would be beyond the scope of this thesis. Therefore the following assumptions have been made:

A. The conflict will be of short duration.

B. Soviet doctrine is reflected in the writings of contemporary Soviet military scholars and current United States Army intelligence assessments.

C. Organizations and equipments currently available to both friendly and enemy forces will be used throughout the conflict.

D. Doctrinal units will be deployed at one hundred per cent strength at H-hour on D day.

The scope of this thesis is limited to the study of the AIM division signal battalion organization as currently assigned in Europe. Moreover, only those assets of the battalion that are directly affected by the Soviet Army communications jamming threat will be discussed. The following responsibilities of the AIM division signal battalion are not considered:

A. The issue, maintenance, and management of Communications Security (COMSEC) material and equipment.

B. Current Communications-Electronics Operating Instructions (CEOI) issue procedures.

C. Division Communications-Electronics (CE) staff responsibilities to manage the entire division CE missions.

D. Maneuver brigade and battalion CE missions.

Only current organizations and equipments will be evaluated. Future deployment of new equipments will not be addressed. This thesis will investigate the problem as it exists on the battlefield today.

Definition of Terms

The following definitions of terms are taken from U. S. Army publications:

Amplitude: the range of a varying quantity, i.e. in the case of a wave, half the distance from the trough to crest (Antennas, p. A-9).

Amplitude Modulation: a means of radio communication in which information is impressed on the radio wave by varying the amplitude (Antennas, p. A-9).

Command, Control and Communications (C^3): used to express the system within a unit to provide the commander control and coordination integration in which to see the battle, plan, and execute combat missions by commicating decisions and updating reports (FM 24-1, p. 1-2).

Decibel (db): a system for describing the ratio of powers (Antennas, p. A-10).

Electromagnetic Compatibility (EMC): that much desired condition when all of our equipment--radios, radars, generators, vehicles (ignition systems, etc.)--operates without interfering with each other (FM 24-1, p. 4-10).

Electromagnetic Energy: that energy pertaining to the combined electric and magnetic fields associated with radiations or with movements of charged particles (FM 24-1, p. 1-2).

Electromagnetic Pulse (EMP): an "electronic wave" generated by a nuclear detonation which induces a current in any electrical conductor. It can temporarily disrupt, overload, and damage unprotected components of electronic equipment (RB 100-33, p. C-3).

Electronic Combat (EC): the offensive employment of EW, designed to disrupt the enemy's use of his electronic systems (RB 100-33, p. 1-2).

Electronic Countermeasures (ECM): actions taken to prevent or reduce the enemy's effective use of the elecromagnetic spectrum. ECM includes jamming and electronic deception (FM 100-5, p. 92).

Electronic Counter-countermeasures (ECCM): actions taken to insure friendly use of the electromagnetic spectrum against electronic warfare (FM 100-5, p. 9-2).

Electronic Jamming: the deliberate radiation, reradiation, or reflection of electromagnetic energy with the object of impairing the use of electronic devices, equipment or systems being used by an enemy (FM 24-1, p. B-5).

Electronic Warfare (EW): military action using electromagnetic energy to determine, exploit, reduce, or prevent hostile use of the electromagnetic spectrum while retaining friendly use of the electromagnetic spectrum. EW is divided into the three categories-ESM, ECM, ECCM (FM 100-5, p. 9-2).

Electronic Warfare Support Measures (ESM): actions taken to search for, intercept, locate and immediately identify radiated electromagnetic energy for the purpose of immediate threat recognition and the tactical employment of forces. Direction finding of radios and radars is an ESM technique (FM 100-5, p. 9-2).

Frequency: the rate at which a process repeats itself. In radio communications, frequency is expressed in cycles per second (Antennas, p. A-12).

Frequency Modulation: a means of radio communication in which information is impressed on the radio wave by varying the frequency (Antennas, p. A-9).

Gigahertz (GHz): a thousand-million (a billion) cycles per second (Antennas, A-12).

Hertz (Hz): one cycle per second (Antennas, p. A-13).

High Frequency (HF): frequencies between 3 MHz and 30 MHz (Antennas, p. A-13).

Ionosphere: a partially conducting region of the earth's atmosphere between 50 km and 400 km high (Antennas, p. A-13).

Kilohertz (KHz): a thousand cycles per second (Antennas, p. A-14).

Megahertz (Mhz): a million cycles per second (Antennas, p. A-14).

Radio Direction Finding (RDF): radio location in which only the direction of a station is determined by means of its emission. Since this technique can be used against all electronic emitters, it is sometimes simply referred to as direction finding (DF) (FM 24-1, p. B-10).

Ultra high frequency (UHF): frequencies between 300 MHz and 3,000 MHz (Microwave, p. 2-1).

Very high frequency (VHF): frequencies between 30 MHz and 300 MHz (Microwave, p. 2-1).

Additional Chapters

Chapter II, AIM Division Signal Battalion, will discuss the doctrinal capabilities and limitations of the signal battalion and how it is doctrinally deployed. An additional area deployment method beyond that described in FM 11-50 is also discussed since the effects of mission, threat, and terrain have altered the deployment practices of some divisional signal battalions in Europe.

Chapter III, Soviet Radioelectronic Combat (REC), discusses the doctrinal deployment of Soviet communications jamming assets. The mission, deployment, and capabilities of enemy communication jammers is explained. Emphasis is on Soviet capability to reach into the AIM division signal battalion area of operation and incapacitate the divisional communications system.

Chapter IV, Analysis, evaluates the effects of the Soviet Army communications jamming threat and how it affects the mission accomplishment of the AIM division signal battalion. A discussion of specifically what signal battalion assets are effected and to what extent the division communication systems are degraded is presented.

Chapter V, A Final Review, summarizes the findings of this thesis and makes appropriate recommendations to overcome or avoid any detrimental affects to the divisional command control communications (C^3) capabilities.

Annex A, Soviet Radioelectronic Combat (U), is provided separately as an integral part of this thesis. Classified information concerning Soviet communications jamming equipment and its effectiveness against U.S. communications-electronic systems is presented as an expansion of the unclassified material presented in the body of the thesis.

This thesis and its classified Annex have been written as separate documents. Each may be read and comprehended in isolation but a greater understanding of the subject material is possible by reading and analysing both documents.

CHAPTER II

AIM DIVISION SIGNAL BATTALION

In this chapter, the mission capabilities and deployment of the armor, infantry, and mechanized infantry (AIM) division signal battalion are examined and discussed. Major communications systems that are installed to provide communications support to the AIM division are explained. The technical characteristics of the primary radio equipment used to provide communications and their vulnerability to communications jamming are presented.

MISSION

The AIM division signal battalion is a four-company, 700 person communications-electronics organization assigned as a subordinate element to each armor, infantry or mechanized infantry division. It is designed to provide a division level communications system capable of supporting the division level functions of command and control, intelligence, fire control, combat support, and combat service support. It provides a signal center and internal command post communications at the division main and tactical command posts and the division support command headquarters. It also provides signal centers located near the division

artillery headquarters and each brigade's logistics support area (FM 11-50, 1977, Chap. 7)

The signal centers provide multiple communication means to insure a reliable communications system that enables the division headquarters to communicate with its subordinate elements. Each signal center provides record traffic communications through the operation of a secure telecommunications center and radio teletypewriter terminals. Voice communication is provided through the utilization of frequency modulated, very high frequency radio terminals; amplitude modulated, single side band, high frequency radio terminals; pulse code modulated, ultra high frequency multichannel terminals; and wire telephone service. The amount and type of communications support is specifically tailored to meet the expected communications requirements at each of the signal centers. Additional radio terminals are provided to designated subordinate headquarters commensurate with mission requirements and the equipment limitations of the AIM division signal battalion (FM 24-1, 1976, Chap. 5).

Signal Centers

The establishment of signal centers at the division headquarters and its subordinate elements provides the

communications user direct contact with personnel and equipment of the AIM division signal battalion. Since each signal center is configured to meet the specific needs of its subscriber, the capabilities of the different types of signal centers vary considerably.

The division main command post signal center provides the most complete multiple communications support facility capable of the AIM division signal battalion. The division main command post is the principle command control information clearinghouse for the division. It requires extensive communication links with its subordinate elements in order to assimilate the details of current combat operations, enemy activities, and to make command decisions concerning current and future combat operations.

The division main command post signal center (Figure 2-1) is installed and operated by the command operations company of the AIM division signal battalion. It provides a secure telecommunications center supporting the division main command post that is located adjacent to the division tactical operations center (DTOC), a telephone switchboard (SWBD), a communications systems planning element (CSPE), and communications systems control element (CSCE), a communications circuit control patch panel and communications nodal control element (CNCE), three radio teletypewriter (RATT)

Division Main Command Post Signal Center

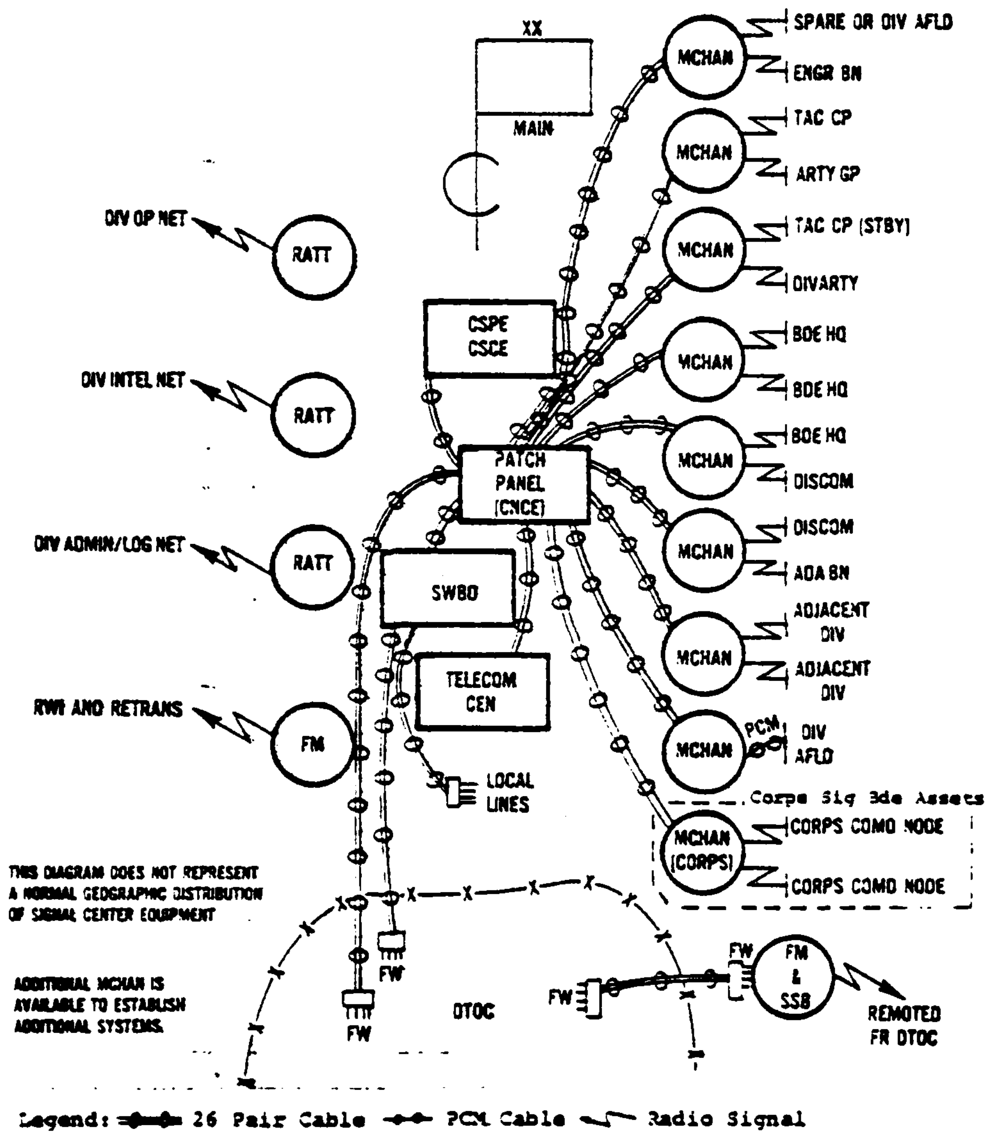


Figure 2-1 (FM 11-50, 1977, p. 7-14)

terminals, one multichannel cable system, fourteen multichannel radio systems, a radio wire integration terminal,

a frequency modulated (FM) very high frequency radio retransmission terminal, and frequency modulated (FM) very high frequency and amplitude modulated high frequency, single sideband (SSB) radio terminals that are remoted from the division tactical operations center (DTOC) (FM 11-50, 1977, PP. 7-13, 7-14).

The division tactical command post signal center is a small, highly mobile signal center designed to support the communications requirements of the division tactical command post. The division commander has the responsibility for the command and control of numerous combat actions throughout his division area. To prevent the destruction of the division's command and control from a single assault or nuclear attack, the division commander establishes tactical command posts well forward in the division area. The tactical command post is primarily concerned with current combat operations and is a principal location for the division commander to see the battlefield and personally influence the battle (TC 101-5, 1976, p.15).

There are two identical tactical command post signal centers. One is actively supporting the tactical command post and the other is passively installed, with its communications equipment turned off, at a preplanned deployment location. Active and passive signal centers are used

to facilitate the frequent relocation of the tactical command post and prevent its identification by the enemy's intelligence units. Two identical signal centers are installed because the set-up time required of current multichannel terminals is too lengthy to enable the tactical command post to relocate as often as desired.

Each tactical command post signal center (Figure 2-2) provides a small telephone switchboard, two radio teletypewriter terminals, two multichannel radio systems, a radio wire integration terminal, and frequency modulated, very high frequency radio terminals, and amplitude modulated, high frequency single sideband radio terminals that are remoted from the tactical command post (FM 11-50, 1977, p. 7-16).

Division Tactical Command Post

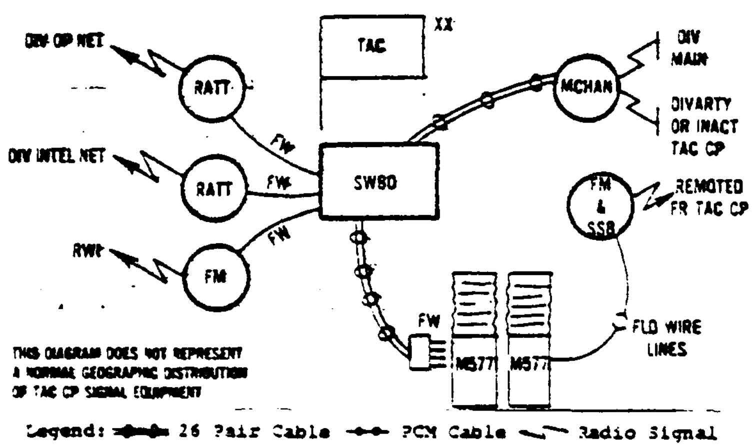


Figure 2-2 (FM 11-50, 1977, p. 7-16)

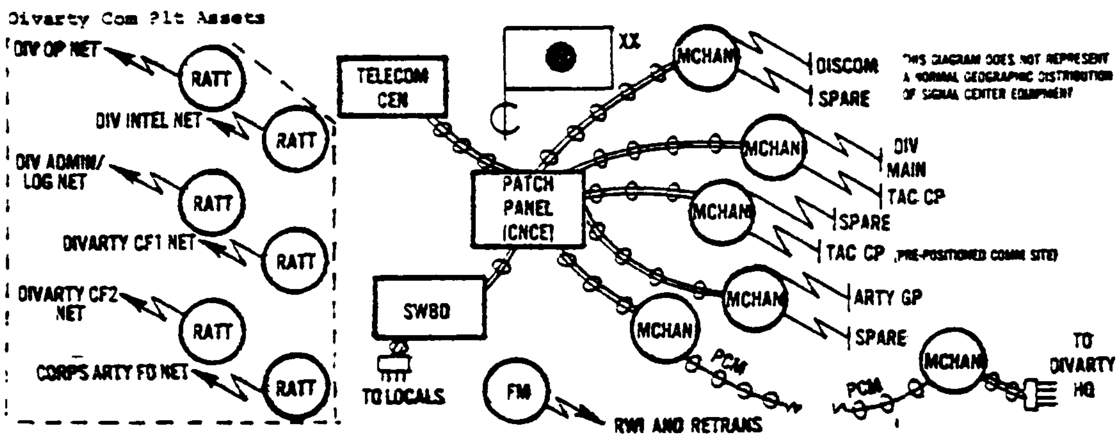
The division artillery signal center has the responsibility of providing communication links between the division artillery headquarters and other subordinate elements of the division. In addition to providing command level communications, the division artillery signal center also has the responsibility of providing communication terminals and circuits in the corps and division artillery fire control nets.

To prevent the division artillery headquarters from being located by enemy intelligence from its physical and electronic signature, the division artillery signal center is normally located a considerable distance away from the division artillery headquarters (FM 11-50, 1977, p. 7-11). The division artillery headquarters is one of those headquarters that may be used as an alternate division headquarters in the event the division main command post becomes incapacitated.

The division artillery signal center (Figure 2-3) is established by the command operations company of the division signal battalion and by the communications platoon of the division artillery headquarters and headquarters battery. The division artillery communications platoon provides six radio teletypewriter terminals. The command operations company of the division signal battalion provides a secure

telecommunications center, a telephone switchboard, a communications circuit control patch panel and communications nodal control element, a radio wire integration and frequency modulated very high frequency radio retransmission station, eight multichannel radio systems, and one multichannel cable system (FM 11-50, 1977, p. 7-11).

Division Artillery Signal Center

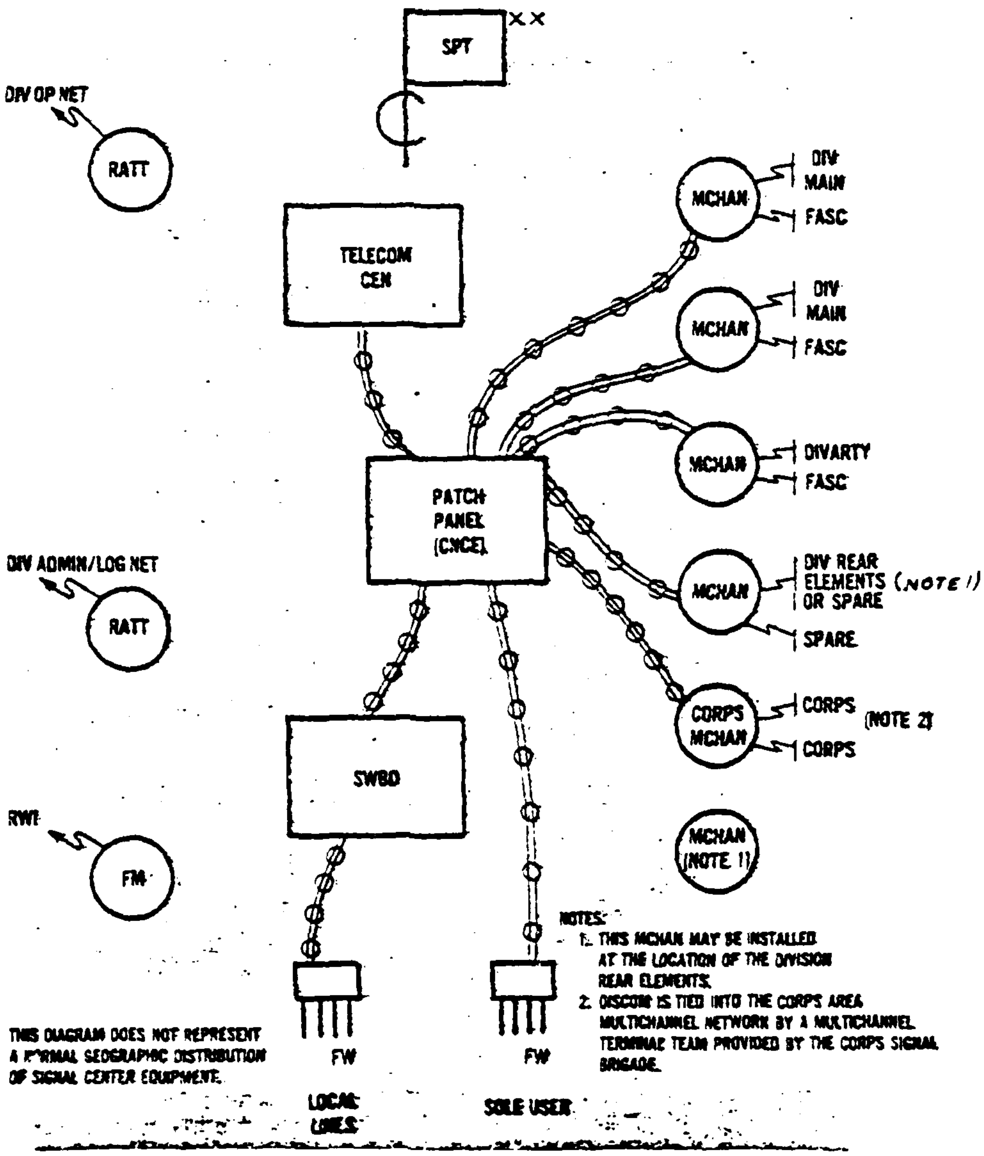


Legend: 26 Pair Cable PCM Cable Radio Signal

Figure 2-3 (FM 11-50, 1977, p. 7-11)

The division support command signal center provides communications support for division support command, command post. It is installed and operated by the signal support operations company of the division signal battalion and is normally located towards the division rear boundary in the division support area. The division support command is

Division Support Command Signal Center



Legend: 26 Pair Cable PCM Cable Radio Signal

Figure 2-4 (FM 11-50, 1977, p. 6-15)

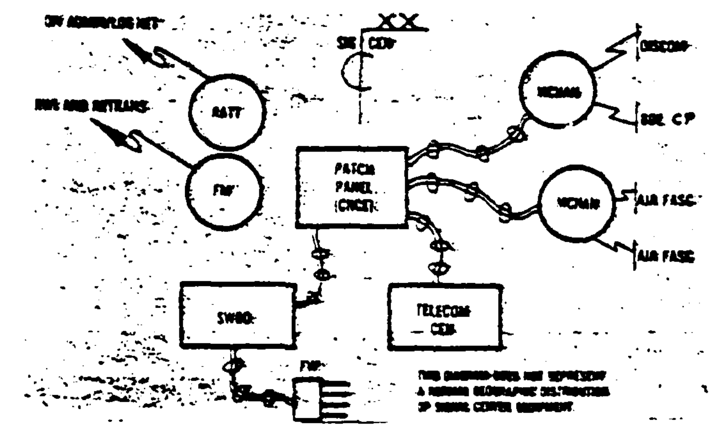
responsible for logistical support of the division and its subordinate elements. Its communications support requirements are derived from the need to provide timely medical, maintenance, supply and transportation support. The division support command accomplishes its mission by assigning forward area support teams from its combat service support battalions and medical battalion to operate in forward areas. The forward area support teams will collocate with the brigade trains of the brigade they are assigned to support. Because of the great distances involved between the forward area support teams and the large volume of logistics information required, the division support command relies greatly on the division signal battalion's multichannel radio and cable systems to communicate with its forward area support teams (FM 11-50, 1977, p. 6-14).

The division support command signal center (Figure 2-4) provides a secure telecommunications center, a telephone switchboard, a communications circuit control patch panel and communications nodal control element, two radio teletypewriter terminals, a radio wire integration station, and eight multichannel radio systems (FM 11-50, 1977, p. 6-15).

Three forward area signal centers are installed and operated by the forward communications company of the division signal battalion. Forward area signal centers are

normally collocated with the brigade support area of the brigade they normally support. Whenever possible a habitual relationship is developed between the forward area signal center platoon and its supported brigade by constantly assigning the same forward area signal center to the same brigade. The brigade support area is normally in the rear of the brigade area and may be located behind the brigade rear boundary in the division area (FM 54-2, 1976, p. 2-7).

Forward Area Signal Center



Legend: 26 Pair Cable PCM Cable Radio Signal

Figure 2-5 (FM 11-50, 1977, p. 6-14)

Each forward area signal center (Figure 2-5) supports the division support command's forward area support team, elements of the brigade located at the brigade trains, a multichannel system to the brigade command post, and

provides area communications to units within its geographical area. It provides a secure telecommunications center, a telephone switchboard, a radio teletype terminal, a communications circuit control patch panel and communications nodal control element, a radio wire integration and frequency modulated , very high frequency radio retransmission station, and four multichannel radio systems (FM 11-50, 1977, p. 6-14).

Radio Terminals

In addition to providing signal centers, the AIM division signal battalion also provides multichannel radio terminals and, in some situations, radio teletypewriter terminals to three subordinate brigade headquarters, the air defense artillery battalion, the division engineer battalion, the corps artillery brigade, the division rear elements and the division airfield area (Jayhawk, 1979, L2-I-15). The multichannel radio terminals link these designated headquarters into the AIM division signal battalion's multichannel system. It provides the division a complete command and control communications system connecting the division commander with every major headquarters in his division area. The radio teletypewriter terminals are configured into command control communications

nets that provide the initial command control communications system while the multichannel system is being installed. After the AIM division signal battalion's multichannel system is installed and operating, the radio teletypewriter nets continue to provide communications service but they are essentially used as a backup system.

Each of the division's subordinate brigades is provided one multichannel radio terminal capable of installing two multichannel systems. The multichannal radio terminal is located at a site near the brigade headquarters. It is installed and operated by a multichannel terminal team from the AIM division signal battalion's forward communications company. This multichannel radio terminal is then connected to both the brigade headquarters and the brigade command post with distribution cables. The installation of the distribution cables is the responsibility of the AIM division signal battalion but, in many cases, they are installed by the brigade's communications platoon. This system provides a communication link between the brigade tactical operations center and the division tactical operation center (FM 11-50, 1977, p. 7-4).

In addition to the multichannel radio terminal, each brigade is also provided two radio teletypewriter terminals by the AIM division signal battalion's forward

communications company. These radio teletypewriter terminals are normally operated in the division operations net and the division intelligence net but may be used for other communications purposes when authorized by the net control station (NCS) (FM 11-50, 1977, p. 7-5).

The division air defense artillery battalion is provided one multichannel radio terminal that is installed and operated by the signal support operations company of the AIM division signal battalion. The multichannel radio terminal is established at a site near the air defense artillery battalion command post. The multichannel radio terminal is connected to the air defense artillery battalion switchboard to provide the air defense artillery battalion headquarters access to the AIM division signal battalion telephone system (FM 11-50, 1977, p. 6-4).

The division engineer battalion is also provided one multichannel radio terminal that is installed and operated by the signal support operations company of the AIM division signal battalion. The same procedure is used to provide the division engineer battalion headquarters access into the AIM division signal battalion telephone system as is used for the division air defense artillery battalion headquarters. Both the division air defense artillery battalion and the division engineer battalion are able to

use the AIM division signal battalion telephone system to contact their subordinate batteries and companies. Their subordinate batteries and companies have access to the same telephone system at the nearest AIM division signal battalion signal center (FM 11-50, 1977, p. 6-2).

Current artillery doctrine provides for the attachment of corps field artillery brigades to AIM divisions when required by the tactical situation. In fact, the attachment of corps field artillery brigades to subordinate divisions is a major planning factor at the corps level. The objective is to provide additional artillery command and control to increase its influence on the battle (Tactics, 1979, LSN5). When a corps field artillery brigade is attached to or placed under the operational control of the AIM division, the command operations company of the AIM division signal battalion is required to provide one multichannel radio terminal at the field artillery brigade headquarters (Jayhawk, 1979, p. L2-I-25). This multichannel radio terminal provides two multichannel radio systems; one to the division artillery signal center, and one to the division main command post signal center. It provides the corps field artillery brigade the ability to utilize the AIM division signal battalion communications systems to interface with the supported division combat elements.

The AIM division rear elements consisting of the division information office, judge advocate general, inspector general, finance company and the adjutant general company are normally located in the division support area. When the division rear elements are located in the division support area, the signal support operations company provides them one multichannel radio terminal. If the division rear elements are located in the corps area then the corps signal brigade provides access to the division multichannel communications system through the corps area communications system. The division rear elements' access to the division's multichannel system is the only factor affected by its location. The AIM division signal battalion's signal support operations company provides internal communication services and one radio teletypewriter terminal at either location (FM 11-50, 1977, p. 6-22).

The aviation battalion of the AIM division has the responsibility of operating the division's instrumented airfield. The aviation battalion has the capability of installing, operating and maintaining its own internal communications system. However, the signal support operations company of the AIM division signal battalion has the responsibility

of providing either one multichannel radio terminal or one multichannel cable system to the division airfield. Normally the multichannel cable system will be installed but if the division airfield is located a great distance from the division main command post, the multichannel radio terminal is installed (FM 11-50, 1977, p. 6-8).

The AIM division signal battalion has a doctrinal responsibility of providing one multichannel radio terminal to the unit on its right (FM 24-1, 1976, p. 5-7). This is necessary to insure the coordination of combat operations between adjacent divisions. U.S. Army doctrine requires that communications liaison terminals are provided on a left to right basis. This means the AIM division signal battalion will send a multichannel radio terminal to the main command post of the unit on its right. When a U.S. division has an adjacent allied unit, then an interoperability agreement between the two units will determine how adjacent communications will be provided (STANAG, 1972, p. 3). This is normally accomplished through the exchange of liaison teams with their own communications assets. Although these communications assets may be of similar design, current allied multichannel radio terminals and radio teletypewriter terminals are not compatible with similar U.S. communications equipments (Jayhawk, 1979, L2-I).

This concludes the mission requirements of the AIM division signal battalion related to the installation of signal centers and radio terminals. Both signal centers and signal terminals provide the communications subscriber access into the AIM division signal battalion multichannel system. How the signal centers and radio terminals are connected by the multichannel system is normally not the concern of the subscriber. He is not aware of how his particular communication service is routed through the multichannel system by its operation. The configuration of the division multichannel system has a direct relationship to the size of the division area, the division's mission, the geographical characteristics of the terrian, and its vulnerability to the Soviet radioelectronic combat threat (FM 11-50, 1977, p. 7-22). Therefore, the current doctrinal multichannel system and one additional multichannel system configuration are presented.

MULTICHANNEL COMMUNICATIONS SYSTEMS

The doctrinal multichannel communications system, as presented in FM 11-50, page 7-23, is shown in figure 2-6. This multichannel communications system is a combination of secure multichannel radio and cable links that are installed, operated and maintained by the command operations, forward

Doctrinal Division Multichannel System

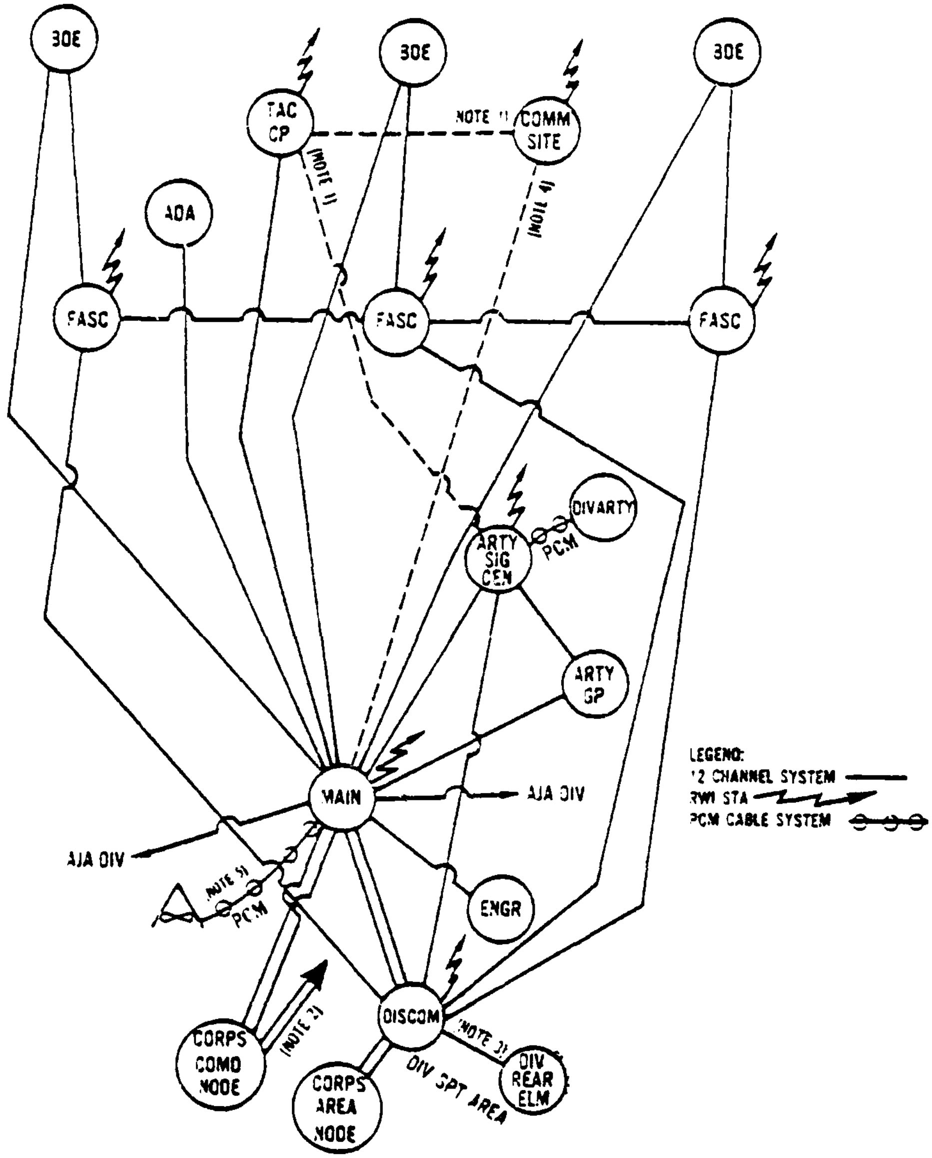


Figure 2-6 (FM 11-50, 1977, p. 7-23)

communications, and signal support operations companies of the AIM division signal battalion. It requires the installation of twenty-four multichannel radio systems and three multichannel cable systems. The multichannel radio systems from corps to division are installed, operated and maintained by the corps signal brigade. The multichannel radio system interconnecting the division on the left will be installed by the signal battalion of that division (FM 11-50, 1977, 7-23).

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[1] These notes apply to the AIM division multichannel systems diagram shown in Figure 2-6.

(1) The multichannel connection between the division TAC CP and the prepositioned communications site or the TAC CP and the divarty signal center is situationally dependent. The connection may be installed to the communications site or the divarty signal center but not both.

(2) This 24-channel connection is installed to the major subordinate command of the division that is designated by the division commander.

(3) This connection is installed only if the division rear elements are located in the division area.

(4) This multichannel connection is a doctrinal system always installed when the preposition TAC CP communications site is in place.

(5) A multichannel radio system will be installed between the division airfield and division main if required by distance.

The doctrinal multichannel communications system requires the utilization of the maximun multichannel radio terminal capacity of the AIM division signal battalion. This does not include the installation of multichannel radio relay terminals (FM 11-50, p. 7-22). It requires forty-eight different ultra high frequencies. Two frequencies are required for each multichannel radio system; one for receiving and one for transmitting. If multichannel radio relays are required, two additional frequencies will be required for each multichannel radio system relayed. Multichannel radio relays are used when a multichannel radio system exceeds the distance limitation of the current multichannel radio or the geographical characteristics of the terrain do not provide a line of sight path between the transmit and receive terminals of the multichannel radio system.

The doctrinal division multichannel system is one of the primary factors taken into consideration during the development of the AIM division signal battalion's table of organization and equipment, TOE 11-35H. The Training and Doctrine Command has the responsibility for the development of the tables of organization and equipment authorizations to accomplish the military missions specified by that doctrine (PT 100-1, 1978, p. 14). However, the multichannel system does not necessarily represent the typical utilization

of multichannel radio equipment for a specific tactical situation. The AIM division signal battalion commander will develop the division multichannel communications system commensurate with the desires of the division commander, the current tactical situation, and the communications assets he has available (FM 11-50, 1977, p. 7-22).

The AIM division signal battalion's multichannel communications system forms the primary tactical communications means between the subordinate brigades and the divisional command and support elements. The multichannel system's principal limitatations are a radio line-of-site propagation path requirement which may require relays for increased range or to overcome hill masses, and the time required to establish the system (Jayhawk, 1979, L2-I-39).

The problems related to the lengthy installation time of the doctrinal multichannel communications system is obvious when a comparison is made between the future command post (CP) displacement objectives, as expressed in FM 24-1, page 6-4, and the signal center displacement factors used in the U.S. Signal Center (USASIGC), Europe 48-hour Short Warning, Phase 11 report, dated November, 1978 (see Table 2-1). The set-up times for the USASIGC's report were based on the standards required in the Army Training and Evaluation Program (ARTEP 11-35) for the AIM division signal battalion and the recent experience of

TABLE 2-1

FM 24-1, Combat communications, future command post displacement objectives.

Echelon	Set-Up	Tear Down
Division	30 min	30 min
Brigade	15 min	15 min
Battalion	5 min	5 min

USASIGC, Europe 48-Hour Short Warning, Phase II Report

Signal Centers	Set-Up	Tear Down
Division Main CP	4 hr	2 hr
Brigade CP	1 hr	30 min
Division TAC CP	45 min	15 min
Forward Area Signal Center	1 hr 30 min	1 hr
Division Support Command	2 hr	1 hr

signal officer advanced course students whose previous assignments were with AIM division signal battalions (Hellstern, 1979). The travel time required for the AIM division signal battalion units to move from their initial assembly areas to their operational sites must be added to the set-up times in Table 2-1 to compute the time required for the initial establishment of the doctrinal multichannel system. AIM division signal battalions are constantly trying other multichannel communications system configurations to improve on their response times.

The First Armored Division, signal battalion's area concept for the multichannel communications system was

studied by the Communications Research and Development Command in September, 1978. A number of variations of the area concept for the installation of the multichannel communications system have been tested by other division signal battalions (Morris, 1979). Its merits are under current debate throughout the tactical communications community and deserve discussion in this thesis.

The 141st Signal Battalion of the 1st Armored Division designed an area concept for the installation of the division multichannel communications system (Figure 2-7) because they had experienced an over-commitment of their multichannel assets in implementing the FM 11-50 doctrinal multichannel communications system. The over-commitment of multichannel assets was caused by the extensive size of the 1st Armored Division's area of operation (100 kilometers by 70 kilometers), the wide dispersion of the 1st Armored Division units when initially deployed, adverse compartmentalized terrain, the additional requirement of providing service to a corps field artillery brigade and armored cavalry regiment, rapid command post relocation requirements, and the use of towns as command posts (Sheffield, 1978, p. 4).

The 141st Signal Battalion's multichannel communications system area concept uses two identical division main signal centers (MSC) which alternately relocate to follow the division main command post. Three area signal centers

141st Signal Battalion Multichannel System

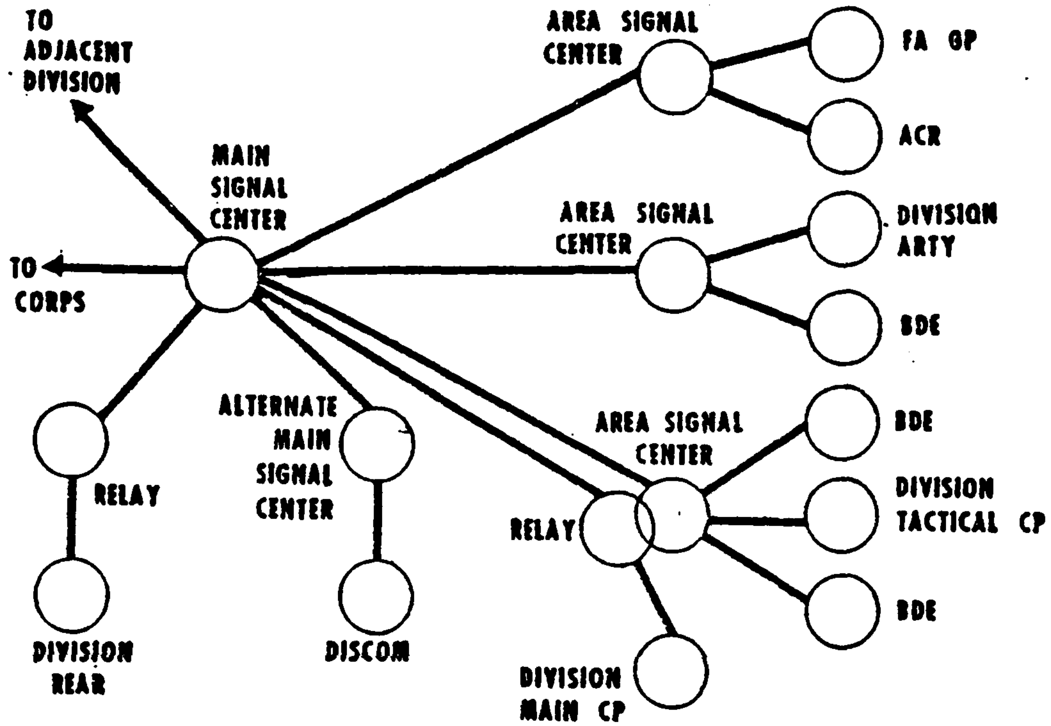


Figure 2-7 (Sheffield, 1978, p. 6)

are deployed to support the major subordinate commands of the division. The division support command, the division rear elements, and the division main command post are directly supported by the two main signal centers (Sheffield, 1978, p. 5).

The 141st Signal Battalion's multichannel communications system area concept does not provide connections between the division main and the brigades, the corps artillery group, and the division tactical command post. The division

support command was not directly connected to the forward area signal centers (141st Signal Battalion ASC's). The forward area signal centers were not collocated with the brigade support area and did not provide lateral connections between them. All of the above multichannel connections are specified in FM 11-50 but had to be deleted to provide a responsive multichannel system for the main signal centers (Sheffield, 1978, p. 5).

The Communications Research and Development Command's evaluation of the 141st Signal Battalion's multichannel system was very critical and quick to list numerous shortcomings of the system. However, it did point out that because of the 141st Signal Battalion's unique mission requirements, the primary deficiencies were due to a shortage of personnel and equipment and not the fault of the design of their area concept for the installation of the division multichannel system (Sheffield, 1978, p. 8).

In conclusion, each AIM division signal battalion develops its own version of the division multichannel communications system tailored to satisfy its particular mission and commensurate with the constraints of available signal assets. Although the division multichannel system has difficulties keeping pace with the frequent relocation of the units it supports, it is

still the primary means of tactical communications within the division (Jayhawk, 1977, L2-I-39).

SINGLE CHANNEL RADIO NETS

Single channel radio nets are operated by every subordinate command in the AIM division. The nets are primarily used for internal command and control within each organization. There are approximately three thousand communications emitters configured into approximately four hundred nets in a U.S. AIM division (FM 24-1, 1976, P. 1-6). The majority of the single channel radio net equipments are operated by either organic personnel of the unit or by members of a communications-electronics section or platoon assigned to the unit. For example, the single channel radio terminals of the division engineer battalion are operated by members of the battalion and communications-electronics personnel assigned to the communications-electronics platoon of the engineer battalion headquarters company. Additional single channel radios are provided by the AIM division signal battalion, the corps signal brigade the U.S. Air Force, and the combat intelligence (CBTI) company (Table 2-2). Combat intelligence companies have been replaced with combat electronic warfare intelligence battalions in some AIM divisions.

TABLE 2-2

Division Single Channel Nets

NET / STATION	DIV COMD/OP NET (FM)	DIV INTEL NET (FM)	DIV WEA NET (FM)	DIV TOC NET (SSB)	DIV OP NET (RATT)	DIV INTEL NET (RATT)	DIV ADMIN/LOG NET (RATT)	CORPS COMD/OP NET (RATT)	CORPS INTEL NET (RATT)	CORPS INTEL NET (SSB)	CORPS WEA NET (RATT)	USAF AIR REQ NET (SSB)	USAF AIR DIR NET (HF)	CORPS RECON/SURVL NET (RATT)
DIV CDR	•													
G3 OP MAIN	•			•	*A			*B				*C	*C	
G2 (INTEL) MAIN		*D	D SWO			*A			•	*D	*D SWO			
G1/G4 MAIN							*A							
DIV TAC CP	•	•		*A	*A	*A				*D		*C	*C	
DIVARTY	•	•		•	•	•	•							
BDE (3 EA)	•	•	WEA TM	•	*A	*A	SEE FASC					TACP	TACP	
[illegible] BN												TACP	TACP	
CAV SQDN	•	•		•	•	•	•					TACP	TACP	
AVN UNIT	•	•	WEA TM		•	•								*D
[illegible] BN	•													
ENGR BN	•	•			•	•	•							
FASC							*A							
DISCOM	•	•			*A		*A							
ADA BN	•	•			•	•	•							
[illegible]		•												
MP CO	•													
DIV REAR							*A							
CBTI CO	•	•												

LEGEND:
A-PROVIDED BY DIV SIG BN.
B-PROVIDED BY CORPS SIG BDE.
C-PROVIDED BY USAF.
D-PROVIDED BY CBTI CO.

NOTE: TWO IDENTICAL SETS OF C-E EQUIPMENT ARE PROVIDED FOR THE DIVISION TACTICAL COMMAND POST BY THE DIVISION SIGNAL BATTALION.

(FM 11-50, 1977, p. 7-18)

The AIM division signal battalion provides single channel radio teletypewriter terminals, frequency modulated, very high frequency, single channel radio terminals and high frequency, single sideband radio terminals in the division

nets shown in Table 2-2. These single channel radio nets provide primary division tactical communications during the initial establishment of the division multichannel system and whenever the multichannel system is degraded because of multichannel radio terminal relocations. Six of the primary divisional command and control nets are shown in figures 2-8, 2-9, 2-10, 2-11, 2-12, and 2-13. The AIM division signal battalion provides the terminals marked with an asterisk (*).

Division Intelligence Net (FM)

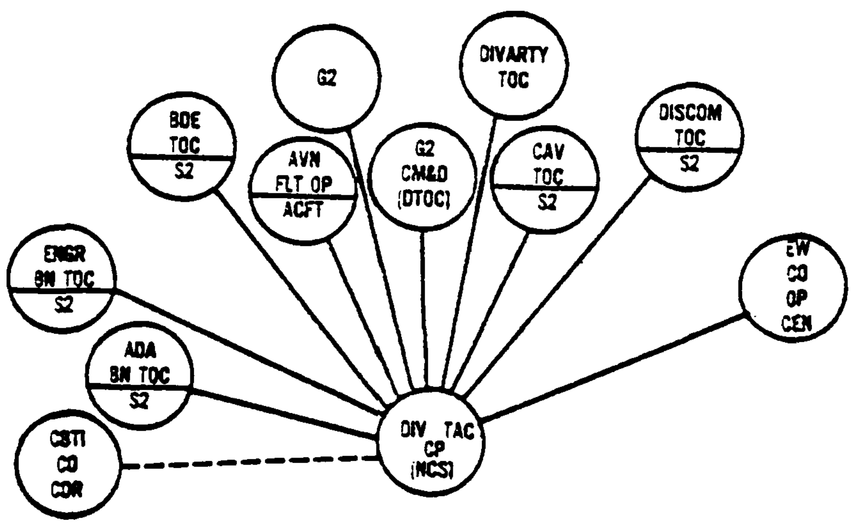


Figure 2-8 (FM 11-50, 1977, p. 7-19)

Division Command/Operations Net (FM)

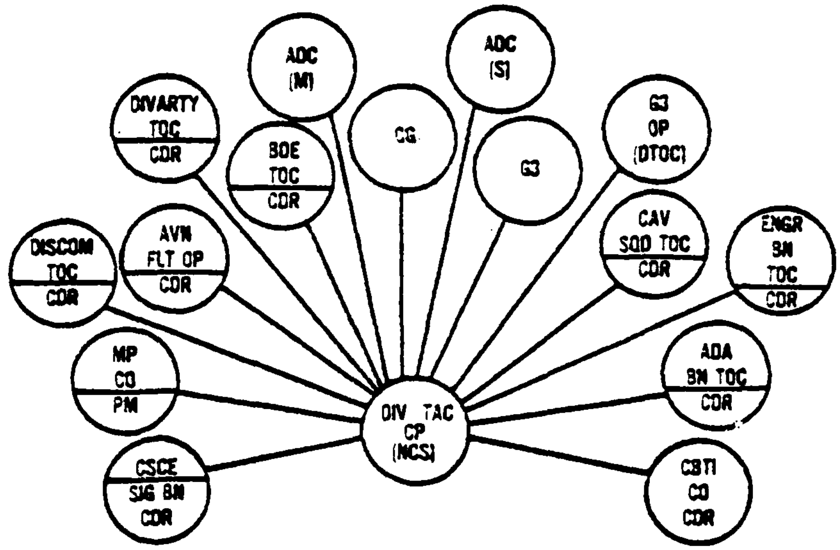


Figure 2-9 (FM 11-50, 1977, p. 7-19)

Division Administrative/
Logistics Net (RATT)

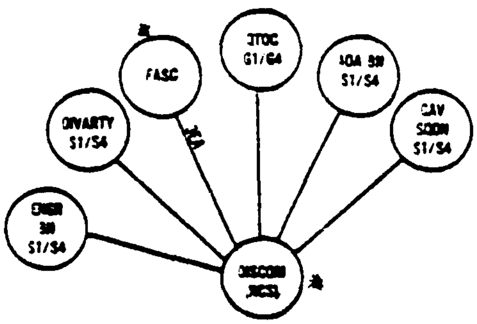


Figure 2-10
(FM 11-50, 1977, p. 7-20)

Division Operations
Net (RATT)

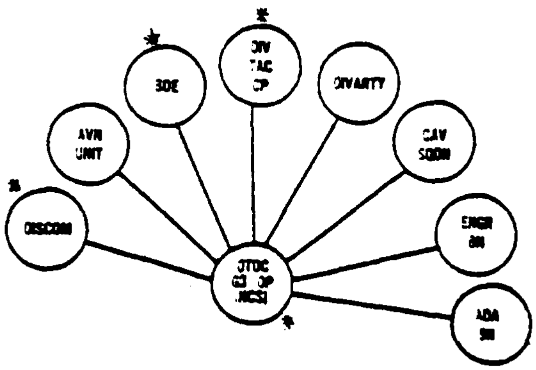


Figure 2-11
(FM 11-50, 1977, p. 7-20)

Division Tactical
Operations Center Net (SSB)

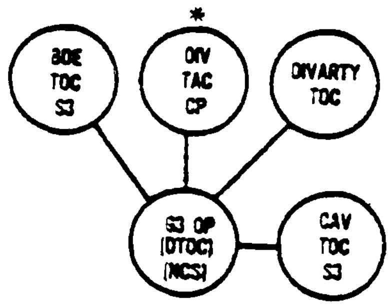


Figure 2-12
(FM 11-50, 1977, p. 7-20)

Division Intelligence
Net (RATT)

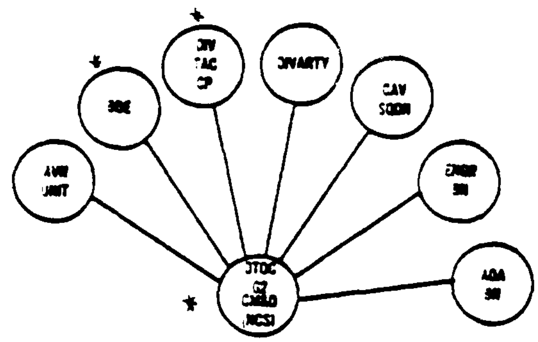


Figure 2-13
(FM 11-50, 1977, p. 7-20)

The importance of providing single channel radio service to designated headquarters in the division must not be underestimated by AIM division signal battalion commanders. These radio nets not only provide a backup communications system for the multichannel system, but at critical times during the conduct of combat operations they provide the quickest means of providing command control communications (FM 11-50, 1977, p. 7-17).

RADIO EQUIPMENT

The radio equipment used by the AIM division signal battalion to install and operate the division multichannel system and the division single channel radio nets are the primary instrument used to externally transmit

communications signals through the atmosphere. It is necessary to understand some of the technical characteristics of those radio equipments before analyzing their vulnerability to communications jamming.

AN/GRC-103 Radio

The division multichannel communications systems use the AN/GRC-103 radio in two different multichannel terminals; the AN/TRC-145 and AN/TRC-113. The AN/TRC-145 terminal contains two AN/GRC-103 radios and the required multiplex, combiner, and ringer converter equipments to transmit two, twelve channel systems or one, twenty-four channel system (ST-154-2, 1974, p. 4-14). The AN/TRC-145 terminals are used to terminate multichannel systems at the division main, division artillery, division support command, division tactical command post, and forward area signal centers. They are also used to terminate multichannel systems at the division rear elements, the air defense artillery battalion, three subordinate brigades, the corps artillery brigade, the engineer battalion, and the division airfield (Jayhawk, 1979, L2-I).

The AN/TRC-113 radio relay terminal contains three AN/GRC-103 radios and three combiners (ST-11-154, 1974, p. 4-14). It requires additional multiplex equipment

in order to be used as a separate terminal. It is normally used as a multichannel radio relay set to extend the coverage and range of the division multichannel system (Jayhawk, 1979, L2-I-34).

The AN/GRC-103 radio set has the following technical characteristics as explained in ST-11-154-2, 1974, page 4-15 and TM 11-5820-540-12, 1967, page 1-2.

TABLE 2-3

Frequency Range:
- Band I ....220.0 to 404.5 MHz (Channels 40-409)
- Band II ....394.5 to 705.0 MHz (Channels 389-1,010)
- Band III....695.0 to 1,000 MHZ (Channels 990-1,600)
- Band IV ...1350.0 to 1,850 MHz (Channels 2,300-3,300)

Channel/frequency Conversion: Channel No./2+200=frequency in MHz
Power Output: 15-25 watts
Planning range: Approximately 80 kilometers
Modulation: Frequency Modulation (FM)
Type of service: 12 or 24 radiotelephone channels with appropriate PCM multiplex equipment.
Minimum transmitter-to-receiver frequency separation: 16.5 MHz (33 Channels)
Antenna: Corner reflector or pyramidal horn
Maximum receiver input at nominal received frequency: -10 dBm
Receiver sensitivity: -94 dBm
Method of propagation: Line of site/Direct Wave

Consider the following facts concerning sound and light wave frequencies. The normal human hearing range is twenty hertz to twenty kilohertz. The normal human voice range is approximately three hundred to three thousand hertz (FM 24-1, 1976, p. B-13). The frequency of visible light is $3X10^9$ megahertz.

Electromagnetic Spectrum

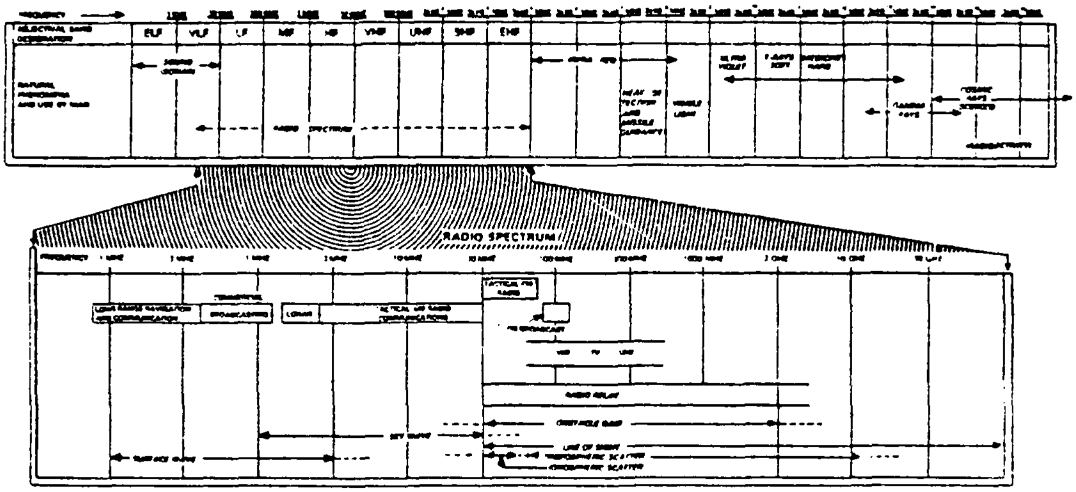


Figure 2-14 (FM 24-1, 1976, Appendix R)

Now that the human voice frequency and the frequency of visible light has been identified, consider the frequency range of the radio spectrum, one megahertz to thirty gigahertz (Figure 2-14). Radio frequencies are impossible to hear with the normal human ear and cannot be seen with the human eye (FM 24-1, 1976, App. R). The AN/GRC-103 radio can both transmit and receive a radio frequency signal that cannot be heard or seen. The method or paths used by a radio to transmit a signal through the atmosphere is defined as the propagagation path of radio frequency energy (Microwave, 1977, pp. 2-1, 2-2). Depending on the frequency of the radio it will use one or more of the five paths of radio propagation shown in Figure 2-15. The

Radio Propagation

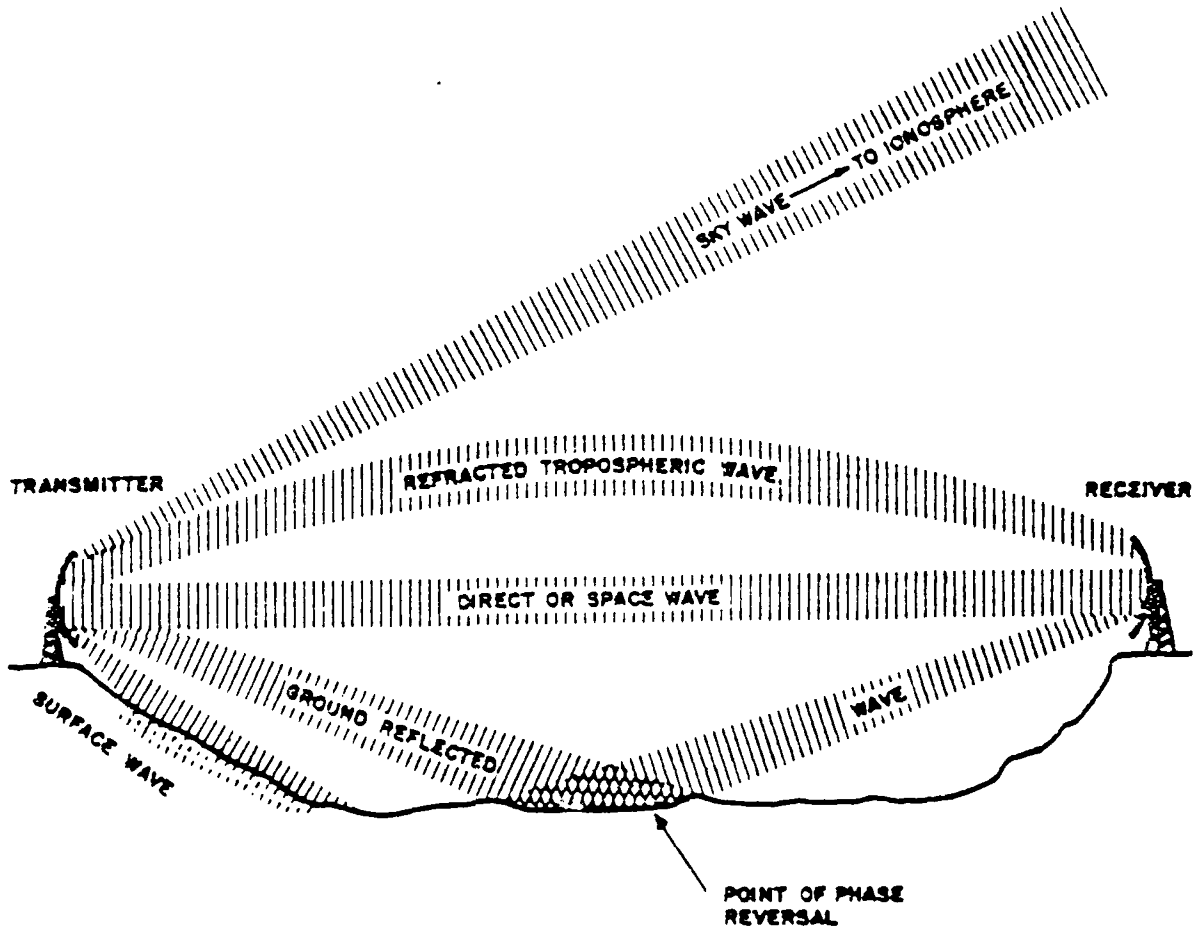


Figure 2-15 (Pictorial, 1979, p.3)

particular propagation path used by a radio is determined entirely by its frequency range.

The AN/GRC-103 radio operates in a frequency range from 220 MHz to 1,850 MHz. Radio frequencies in this range are commonly refered to as ultra high frequencies and use the direct wave propagation path. The direct wave propagation

path is also defined as line-of-site propagation. The ultra high frequency transmission of radio frequency energy using line-of-site propagation is affected by the path length, the operating frequency, transmitter output power, antenna gain, and the receiver sensitivity (Microwave, 1977, Chap. 2).

The path length of a line-of-site signal is limited by the curvature of the earth and the free space attenuation of radio frequency energy. The line-of-site distance is the straight-line distance from the transmit antenna to the radio horizon. The radio horizon is extended beyond the earth's actual horizon by the refraction of radio waves in the earth's atmosphere. Under normal atmospheric and climatic conditions, the straight line distance of the earth's curvature can be increased by a factor of four thirds or 1.33. Although this increases the distance capacity of line-of-site propagation, the distance limitation of current U.S. Army ultra high frequency radio systems is still approximately eighty kilometers. The obstruction of a line-of-site signal by hill masses, severely rolling terrain or tall trees will prevent the transmission of line-of-site signals to the desired distant location (Microwave, 1977, Chap. 2).

Obstructed Line-Of-Site Path

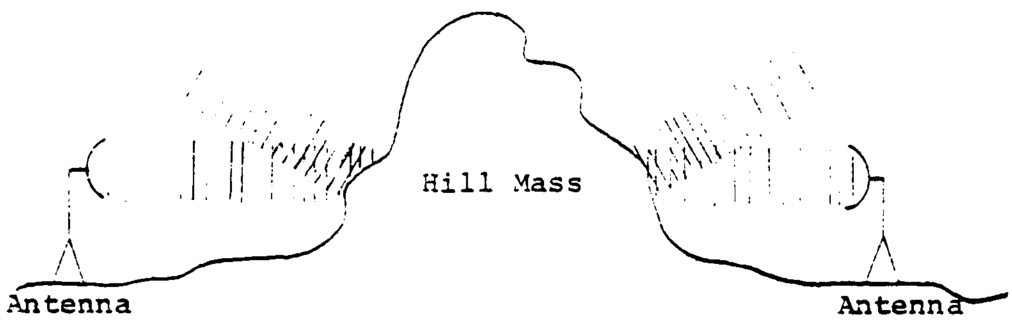


Figure 2-16

This explains why tactical line-of-site communication systems have installation difficulties when deployed in rugged terrain. This problem may be overcome by the installation of radio relays when their installation will furnish the required line-of-site path between the distant terminals (Jayhawk, 1979, L2-I). This also explains the advantage of the electronic counter-countermeasure (ECCM) of installing line-of-site radio systems so that they are obstructed or masked from the enemy forces radio direction finders (Bowman, 1980, p. 7).

Masked Line-of-Site Path

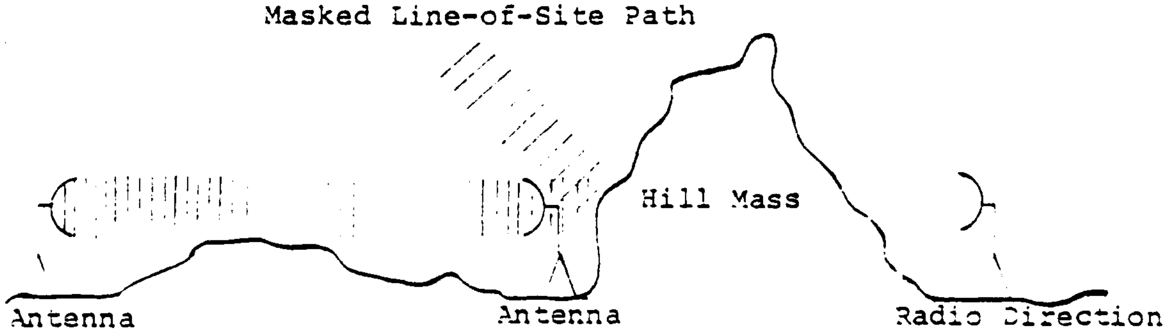


Figure 2-17

The other limiting factor of line-of-site propagation is the free space attenuation or loss of radio frequency energy due to the spreading of that energy over a greater area as the transmission distance is increased. The loss of energy is directly related to the operating frequency and the transmission distance. The formula (Microwave, 1977, p. 2-2) for calculating free space loss is:

$$L_{fs} = 37 + 20 \log F + 20 \log D$$

Where: L_{fs} is the free-space loss in decibels.

F is the frequency in MHz.

D is the transmit distance in miles.

Using this formula and the communications systems engineering techniques explained in Microwave, 1977, Chapter Two, it is possible to determine the line-of-site propagation loss at an assigned frequency for any distance. Example calculations provided in Microwave, 1977, Chapter Two, show that ultra high frequencies can be acceptably transmitted up to 100 mile distances. Normal line-on-site paths are much less than 100 miles but the use of hill masses have provided acceptable line-of-site paths much greater than required in a doctrinal division area of operations, 45 kilometers by 30 kilometers (FM 24-1, 1976, p. 6).

In comparing the limiting factors of line-of-site propagation and free space propagation loss, the following

conclusion can be made. The requirement of a line-of-site propagation path is the major factor in achieving acceptable multichannel radio systems. The AN/GRC-103 radio has the capability to transmit a receivable signal much greater distances than required in the division area. This means that careful selection of line-of-site propagation paths must be accomplished to prevent transmitting usable signals across the forward edge of the battle area. The utilization of obstructing terrain is an absolute requirement to mask the AN/GRC-103 transmit signal and prevent its detection by the enemy's electronic countermeasure assets.

AN/VRC-12 Series Radios

The AIM division signal battalion uses the AN/VRC-12 series of radios to provide the frequency modulated very high frequency single-channel radio terminals and relays described earlier in this chapter. The AN/VRC-12 radio series has the following technical characteristics as explained in ST-11-154-2, 1974, pages 1-10 through 1-19.

TABLE 2-4

Frequency range: Band A-30 to 52.95 mhz
Band B-53 to 75.95 mhz
Number of channels: 920, spaced every 50 khz
Power output: Low-8 watts
High-35 watts
Planning range: Low-approximately 8 km
High-approximately 41 km
Modulation: Frequency Modulation (FM)
Method of propagation: Line-of-site/Direct wave
Type of service: Single channel voice and X mode
Squelch: 150 Hz Tone (new), and noise carrier (old)
Remote operation: Uses AN/GRA-39 or AN/GRA-6 with cable assembly Cx-7474U
Retransmission: Uses C-2299/VRC and 2 radio sets
Tuning: Detent
Antenna: 10 ft vehicular whip or stationary ground plane
Radio set configurations

Components (VRC)..	12	43	44	45	46	47	48	49
RT -246/VRC	1	1	1	2	0	0	0	0
R -442/VRC	1	0	3	0	0	1	2	0
RT -524/VRC	0	0	0	0	1	1	1	2
MT-1029/VRC	1	1	1	2	1	1	1	2
MT-1898/VRC	1	0	2	0	0	1	2	0
C-2299/VRC	0	0	0	1	0	0	0	1
AT -912/VRC or AS-1729	1	1	1	2	1	1	1	2

ST-11-154-2, 1974, page 1-10 also provides the following general information of the AN/VRC-12 family of radio sets:

> The radio sets in the AN/VRC-12 family are short range vehicular and fixed radio sets designed for general tactical use. They provide frequency modulation (FM) radiotelephone communications and can be used with secure voice and digital data equipment using the x-mode facility of the radio sets. Two of the sets, AN/VRC-45 and AN/VRC-49, have retransmission capability...different combinations of basic components form eight radio set configurations, AN/VRC-12,43,44,45,46,47,48 and 49.

The eight radio set configurations are shown in table 2-4. The table lists the receiver (R) and receiver-transmitter (RT) components forming each radio set. The AIM division signal battalion uses the AN/VRC-46, 47 and 49 radio sets to provide communications support to the division and for internal command and control of the battalion (Jayhawk, 1979, L2-I).

The AN/VRC-12 radio series radio set uses the very high frequency range and the line-of-site propagation path. The very high frequency range has the same predominant limiting factors as described for the ultra high frequency range. The most restrictive limiting factor is the line-of-site propagation path requirement. The use of hill masses and other masking terrain features to reduce the transmission of signals across the forward edge of the battle area is also required when operating AN/VRC-12 series radio sets (Bowman, 1980, p. 7). Although the planning range of these radio sets is defined as a maximun of forty-one kilometers, the radios transmit a signal that may be intercepted by radio direction finders at much greater distances. Transmissions using the low power setting may be intercepted at distances up to thirty kilometers. Airborne interception is possible at eighty kilometers when using the high power setting (TC 30-22, 1978, p. 47). The AN/GRC-12 series radio sets have only the two power settings shown in table 2-4.

The AN/VRC-12 radio sets are currently issued and operated with vertically polarized omnidirectional antennas. This means the transmission of radio signals are horizontally emitted equally in all directions. This works well for communications between moving vehicles and in nets comprised of widely dispersed fixed stations but increases their vulnerability to enemy electronic countermeasures (TC 30-22, 1978, p. 49). Directional, horizontally polarized antennas should be used whenever possible. Horizontally polarized antennas radiate in a vertical plane and provide directivity. This reduces the transmission of the radio signal in an undesired direction. It also reduces the vulnerability of interception by enemy forces radio direction finding stations (TC 30-22, 1978, p. 49). The use of directional horizontally polarized very high frequency antennas offers many advantages in an electronic warfare environment. Training circular 30-22, 1978, pages fifty-one and fifty-two, lists the following advantages of directional horizontally polarized very high frequency antennas.

> The horizontal antenna produces a more stable signal in the presence of interference (jamming).
>
> The horizontal antenna produces a more stable signal when used in or near dense woods.
>
> The horizontal antenna is more readily camouflaged without loss of signal.
>
> Small changes in antenna location do not cause large variations in signal strength.
>
> The horizontal antenna is less susceptible to direction-finding because of polarization, and because its signal can be directed to intended recipients and away from enemy radio-direction finding (RDF) in most instances.

The construction of directional horizontally polarized antennas by the AIM division signal battalion is strongly suggested by the majority of electronic warfare literature. Their use with the AN/GRC-12 series radio sets is not only a technical possibility but a practical electronic counter-counter measure. Technical information for the construction of directional very high frequency antennas is readily available in current military publications. There are many that can be constructed from expendable materials in any signal unit, i.e. doublet and long wire antennas (Antennas, 1978, Chap. 7).

The AN/VRC-12 series of radio sets uses frequency modulation because it provides voice transmissions that are clear, distinct, and free of interference. This is accomplished by the limiter and detector stages of the receiver; Figure 2-18.

FM Receiver

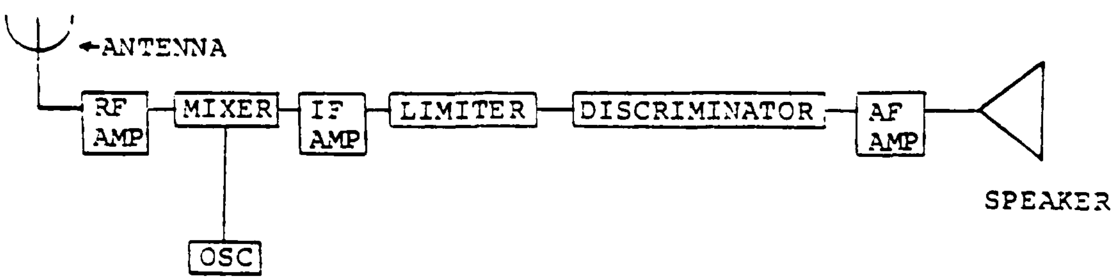


Figure 2-18

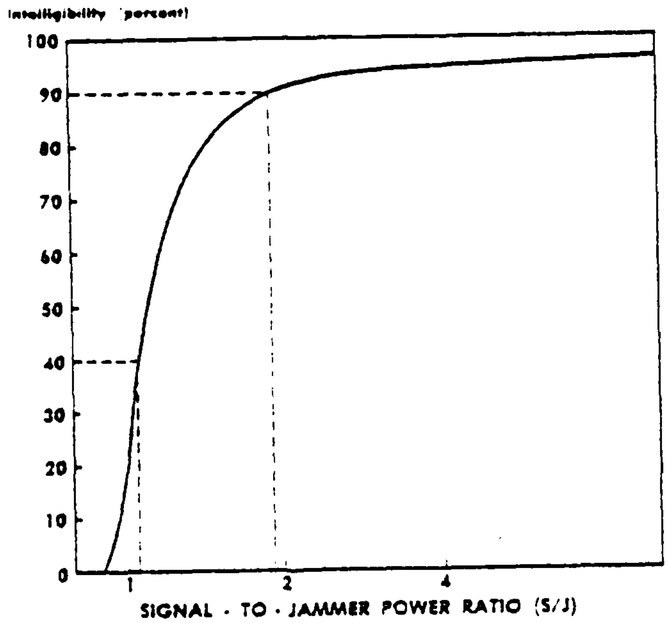
Major Richard A. Platt, in his article, "Electronic Warfare-Punching Back With Tactical FM Radios", described how the clipping off or limiting feature of a frequency modulated receiver actually makes it dangerously vulnerable to enemy jamming (Platt, 1977, p. 11). Interference is received by the antenna of a radio receiver as an undesired voltage. In both amplitude modulation (AM) and frequency modulation (FM), the interfering voltage causes a change in the amplitude of the desired signal. Amplitude modulation transmits the desired signal through the same type of amplitude variations. The interfering signal combines with the desired signal and is heard as interference. Since both the desired and the interfering signals are received as amplitude variations, they cannot be discretely separated.

Frequency modulation transmits the desired signal through frequency variations. The amplitude variations caused by the interfering signal can be filtered out by the limiter stage of the frequency modulation receiver by clipping off or limiting the amplitude of the signal. This results in interference free reception because the desired signal is contained in the frequency variations. Frequency modulation is able to completely overcome interfering signals of the same frequency when the desired signal is only twice as strong. Amplitude modulation requires the desired signal to be one hundred times stronger than an interfering signal

of the same frequency to provide interference free reception (Platt, 1977, p. 10).

As long as the two to one (2:1) signal to interference ratio is maintained, frequency modulation (FM) reception will be free of interference. Once the signal to interference ratio of two to one (2:1) is lost, voice intelligibility rapidly deteriorates because the interfering signal becomes strong enough to affect the characteristics of the resultant signal, Figure 2-19.

Signal-To-Interference Ratio



Desired Signal Power to Jamming Power Ratio
versus Intelligibility at the receiver input

Figure 2-19 (Jayhawk, 1979, L3-III-6)

When the interfering signal becomes twice as strong as the desired signal, it becomes the dominant signal and the desired signal is completely lost. This phenomenon is commonly referred to as the "capture effect" because of the interfering signal's ability to completely capture the resultant signal of the receiver. It also means that it only takes twice as much power for a jammer to completely disrupt a desired frequency modulated signal. The very same feature that makes frequency modulation clear, distinct, and free of interference results in greatly increased vulnerability to enemy jamming or deception operations (Platt, 1977, p. 11).

AN/GRC-106 Radio

The AIM division signal battalion uses the AN/GRC-106 radio set to provide amplitude modulated (AM), high frequency (HF) single-channel voice or radioteletypewriter terminals between widely displaced division units as explained earlier in the chapter. The AN/GRC-106 radio has the following technical characteristics as explained in ST-11-154-2, pages 2-14 and 3-11, and TM 11-5820-520-12, pages 1-1 through 1-6.

Table 2-5

Frequency range:	2.0 to 29.999 MHz
Number of channels:	RT-662/GRC 28,000, spaced every 1 KHz RT-834/GRC 28,000, spaced every 100 Hz
Planning Range:	Ground wave up to 80 km Sky wave 600 to 2,400 km
Type of service:	Upper sideband and upper sideband compatible amplitude (AM) voice, continuous wave (Morse Code), frequency shift keyed and narrow frequency shift keyed teletypewriter.
Power output:	Voice 400 watts PEP Continuous wave 200 watts PEP Frequency shift keying 200 watts PEP
Antenna:	15 foot vehicular whip or doublet antenna AN/GRC-50.
Modulation:	Amplitude modulation
Tuning:	Digital

The AN/GRC-106 radio set uses both ground wave and sky wave propagation paths characteristic of the high frequency (HF) range (Figure 2-19). The ground wave propagation path of the AN/GRC-106 has a maximum range of eighty kilometers. The effective range of ground waves depends on the transmitter power output, type of antenna, atmospheric refraction and diffraction of the waves, the conductivity of the local terrain, and local weather conditions. Ground wave propagation is a combination of the direct waves, ground-reflected waves and surface wave propagation paths (Figure 2-14). The AN/GRC-106 radio set uses groundwave propagation to provide both voice and radioteletypewriter communications within the division area of operations.

GROUND WAVE & SKY WAVE TRANSMISSION PATH

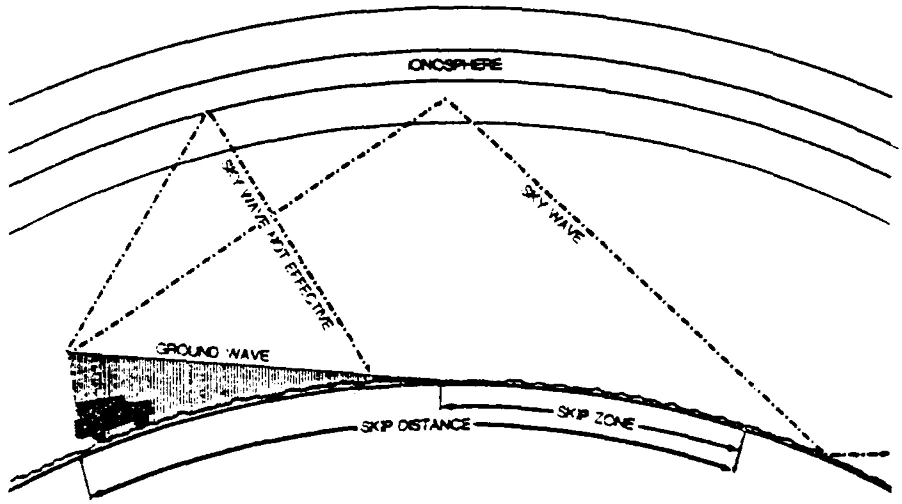


Figure 2-20 (FM 24-1, 1976, p. Q-1)

The AN/GRC-106 radio set also transmits the sky wave propagation path which uses the ionosphere to refract sky waves back to the earth. This greatly increases the effective range of the radio set, as shown in table 2-5, but also creates an area called the skip zone where communication is not possible (Figure 2-20). It is possible to communicate with a near station by ground wave and distant stations by sky wave, but not be able to communicate with a station between the two because it lies in the skip zone of the operating frequency (FM 24-18, 1965, p. 30).

The ionosphere compacts during darkness and expands during daylight. The refractive quality of the ionosphere

increases with its density, thus improving the quality of skywave propagation during the hours of darkness. The sky wave propagation path travels great distances through the atmosphere and is significantly affected by meteorological conditions. Other factors, such as terrestrial location and sunspot activity, also have an impact on the quality of sky wave propagation. The selection of useable frequenc in this frequency range is so complicated it has been computerized. Because some of the varying factors cannot always be predicted; i.e., weather conditions, the assignment of usable frequencies for the operations of AN/GRC-106 radio sets sometimes fails to provide adequate communications quality (FM 24-18, 1965, pp. 34-40).

The AN/GRC-106 radio set's vulnerability to communications jamming is very great. The use of very high power fixed communications jammers is possible because the sky wave propagation path allows them to be located great distances behind the forward edge of the battle area. The high power, 400 watts PEP, of the AN/GRC-106 makes it extremely vulnerable to interception because there are no effective means to mask a sky wave signal (Bowman, 1980, p. 9). Logical conclusions concerning the vulnerability of high frequency (HF) radios resulted in their deletion from the Integrated Tactical Communication System to be fielded in the late 1980's and early 1990's (Rienzi, 1976, p. 15).

SUMMARY

The AIM division signal battalion has an extremely complex mission requiring it to provide a comprehensive command and control communications system for the AIM division. This communications system provides a series of signal centers and terminals using all forms of subscriber services. The signal centers and terminals are linked together with high frequency, very high frequency, and ultra high frequency nets comprised primarily of three basic radio sets; the AN/GRC-103, AN/GRC-106, and AN/VRC-12 series radios. These radios present the primary vulnerability to communications jamming because it is their radio frequency signal emitted into the atmosphere that may be intercepted, analyzed and subsequently jammed by the enemy's radioelectronic combat assets.

CHAPTER III

SOVIET RADIOELECTRONIC COMBAT (REC)

In this chapter, the historical importance of communications jamming and its effects on the development of current Soviet radioelectronic doctrine is discussed. The capabilities of current radioelectronic combat assets and their effect and interaction with both U.S. and Soviet command and control communications systems are examined.

History

Soviet ideas concerning the use of communications jamming were first stated as early as March, 1903. When the Soviet inventor of radio, Professor A. S. Popov, informed the Russian war ministry that the installation of a direct radio link along the Romanian coast would make it vulnerable to eavesdropping and disruption of communications. The first Soviet attempt to actively jam an enemy radio communications system occurred during the Russo-Japanese War. In 1905, the Soviet cruisers, Izumrud and Gromkiy, used their ship's radio transmitters to jam radio communications of Japanese naval ships in the Tsushima Strait (Grankin, 1975, p. 3).

In 1917, V. I. Lenin, became extremely irritated about the use of communications jamming against his

broadcasts by the British and their allies. He directed Soviet scientists to build a high-powered radio transmitter that could not be jammed by neighboring countries (Grankin, 1975, p. 5).

In World War II the Soviet army was successful in jamming and deceiving the encircled German 6th Field Army at the Stalingrad front. This was accomplished by the formation of a radio jamming group and the activation of an independent radio battalion specifically for the purpose of intercepting, jamming, and deceiving the German 6th Army headquarters. Beginning in 1943, the Soviet Army began forming special radio jamming units. These units were able to jam German radio communications throughout the army, corps and division echelons. The most successful jamming operation was conducted in the Belorussian Operation when the German garrison at Koenigsberg eventually surrendered because they were unable to communicate and coordinate their operations with their higher headquarters (Grankin, 1975, pp. 8, 9). Numerous other examples are also cited by Professor Grankin in his article "From The History of Radio Electronic Warfare" to emphasize the Soviet communications jamming efforts prior to and during World War II.

The events of World War II in Russia established the basic foundation for their military thinking. Major J. C. Arnold, in his article "Current Soviet Tactical Doctrine: A

Reflection of the Past", Military Review, May, 1964, pointed out the fact that the Soviets view their military history very seriously. He stated, "Even though modern Soviet doctrine is tempered by speculation as to the nature of modern war, it remains inexorably tied to the Great Patriotic War experiences" (Arnold, 1977, p. 23).

The importance of all forms of Soviet radioelectronic warfare on the modern battlefield became clearly evident during the 1967 and 1973 Mid-East Wars. Edgar O'Ballance, in his book The Electronic War in the Middle East, 1974, primarily discusses electronic warfare related to Egypt's air defense system along the Suez Canal during the 1968-1970 time period. However, Mr. O'Ballance made the following deductions concerning the nature of electronic warfare which were also related to its use by ground forces:

> ...progress in sophistication of weaponry and equipment is inevitable, and that for every electronic advance that brings an advantage to one side or the other a counter will be sought and eventually found.
>
> ...electronic warfare is a highly specialized subject, requiring specialized training and special aptitudes to develop the battle techniques of jamming, counter-jamming, deception and avoidance...
>
> ...electronics cannot entirely replace men...
>
> ...electronics in warfare have come to stay and their degree of involvement will only be limited by the wealth, resources and technical capability of the country concerned, or its ability, like that of Egypt and Israel, to persuade larger nations to supply them with electronic military means.

Mr. O'Ballance's analysis was borne out significantly by an even more intense electronic warfare battlefield during the

1973 Middle-East war. The use of Soviet equipment and tactics by the Arab forces, and the Israelis use of U.S. and allied equipments in the 1973 Middle-East war provided alarming information concerning the effectiveness of Soviet radioelectronic combat equipments when deployed against comparable U.S. equipments (IAG, 1978, p. 5-82). Intensive study of the use of electronic warfare equipments during the 1973 Middle East War caused an increase in the U.S. Army's budget for electronic warfare equipment research and development beginning in 1974 (Meyer, 1974, p. 27).

The Soviet army's dedication to radioelectronic combat began in the early 1900's with allied jamming of Lenin's radio broadcasts. It was further elevated as a Soviet combat multiplier by its successful use during their Great Patriotic War, World War II. Finally, the most recent conflict reflecting the importance of radioelectronic combat, the 1973 Middle-East War, clearly indicates they have continued to develop and expand its use to the extent it presents a significant threat to U.S. forces.

CURRENT RADIOELECTRONIC COMBAT THREAT

The Soviet term for electronic warfare is "Radioelectronic combat". "'Radioelectronic combat' is the use of signals intelligence, intensive jamming, deception and

suppressive fires to deprive their adversary of command and control" (TC 30-22, 1978, p.4). Soviet radioelectronic combat efforts are directed against the following targets in the priorities listed. (RB 100-33, 1978, pp. 2-1, 2-2):

1. Artillery, missile, and air force units that possess nuclear capabilities, and their associated command and control systems.
2. Command posts, observation posts, communications centers, and radar stations.
3. Field artillery, tactical air, and air defense units limited to conventional fire power.
4. Reserve forces and logistics centers.
5. Point targets that may jeopardize advancing enemy forces.

The AIM division signal battalion provides communications systems support to units in the top four target priorities.

The location and "destruction of U.S. Army command and control centers and their associated electronic equipment is an integral part of Soviet radioelectronic combat planning" (RB 100-33, 1978, p. 2-2). The Soviets realize that attempts to destory enemy's command and control centers may only enhance the enemy's efforts and, therefore, attempt to conduct their destruction during time sensitive situations. When targets are unable to be destroyed because of a lack of artillery assets or other fire power means, the Soviets will then use communications jamming techniques to disrupt their command and control communications. Current

estimates of Soviet radioelectronic combat doctrine indicate they will attempt to disrupt fifty to seventy percent of their enemy's command and control communications through either destruction or communications jamming (Jayhawk, 1979, LSN3).

Radio Direction Finders

In order to locate targets, the Soviets use a technique called radio direction finding. The radio direction finding assets are closely tied with artillery units and communications jamming teams (Bowman, 1980, p. 4). Because of their location near the forward edge of the battle field, U.S. Army battalion and brigade level combat units are faced with a greater threat of destruction than units located further distances from the forward edge of the battle area. The primary threat to division level units and their communications system is communication but they are also vulnerable to destruction when located (Bowman, 1980, p. 5).

Neither the destruction by artillery fire or the disruption of communications jamming can be accomplished without accurate radio direction finding assets. Ground based direction finding is imprecise over long distances but the use of airborne direction finders and close in,

ground based direction finders provide adequate accuracy for the targeting of radio transmitters.

Radio direction finders currently used by the Soviet and Warsaw Pact armies are manually operated and require the intersection of three or more bearings from the transmitting antenna for accurate triangulation of targets (Bowman, 1980, p. 5). They also require line-of-site paths to the transmitting stations. Terrain, which masks radio signals and eliminates one or more of the line-of-site paths to the radio direction finders' locations, greatly decreases their ability to determine precise transmitter locations (TC 30-22, 1978, p. 26). Current Soviet built very high frequency radio direction finders primarily use vertically polarized loop and adcock type antennas. While these antennas are especially reliable when identifing the azimuth of vertically polarized signal, horizontally polarized signals will cause them to become inaccurate and give false azimuths (TC 30-22, 1978, p. 21).

Horizontally and vertically polarized antennas that are highly directional also cause inaccuracies in radio direction finder readings. A highly directional antenna focuses its energy along a narrow path . In order for the radio direction finding equipments to obtain the three azimuths required for

accurate target location, they must be located close enough together that each can receive the narrow beamed directional signal. By narrowing the distance between the radio direction finder sites greater errors in accuracy are created because it becomes much more difficult to determine the linear distance from the radio direction finder sites to the transmitter (Figure 3-1).

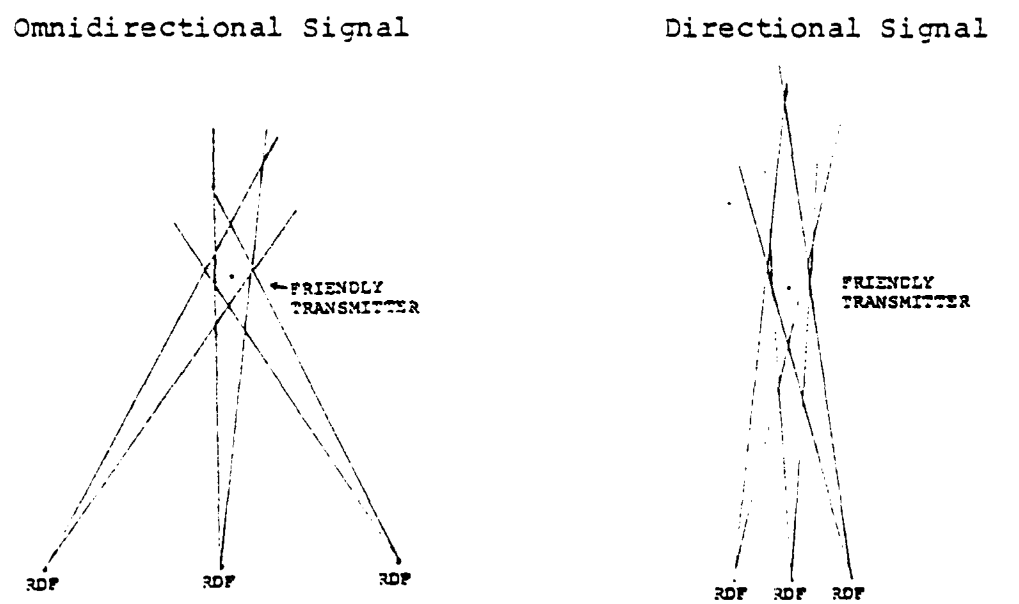


Figure 3-1

Since the radioelectronic combat threat begins with enemy attempts to locate U.S. transmitters, the identification of other factors which cause radio direction finder error is necessary. TC 30-22, 1978, identifies "radio wave propagation irregularity, radio direction finder and emitter

equipment inconsistencies, and radio direction finder operator mistakes as the chief causes of radio direction finder error" (p. 26).

Radio wave propagation error is caused because radio waves may be reflected by terrain features. The combination of the straight line-of-site wave path and additional reflected wave paths reaching the radio direction finder site simultaneously causes an effect called "multipath error". The same signal will arrive at the radio direction finder in different phases making it difficult for the radio direction finder operation to determine the true signal. Azimuth errors, up to ten degrees, may occur because of multipath propagation. Multipath error of very high frequencies can be caused by other metal equipment located near the radio direction finder site, manmade obstructions, or rugged terrain. The technique used to deliberately cause multipath error by locating radio transmitters near hill masses and other rugged terrain features that cause radio wave reflection, is called masking (TC 30-22, 1978, p. 27).

The tactical radio direction finder equipments used by the Soviet and Warsaw Pact armies have an operational accuracy of plus or minus 3.5 degrees or a total accuracy of seven degrees. Strategic radio direction finder equipment used by the Soviets is usually not more accurate than a

plus or minus two degrees or a total of four degrees. Strategic radio direction finder equipments are normally targeted against high frequency equipments and are located well behind the forward edge of the battle area. The great distance between friendly high frequency transmitters and the Soviet radio direction finders results in a much larger linear error and a circular error radius of approximately fifty kilometers. Although it is difficult to accurately locate high frequency transmitters for destruction, the Soviets have successfully been able to detect major troop movements and their vulnerability to communications jamming is great (TC 30-22, 1978, p. 27).

Radio direction finder operator errors are just the application of good old Murphy's Law; if something can go wrong, it will. Soviet radio direction finder operator personnel are required to perform many finite operational and land navigation functions. Any small mistake in one of their required functions can result in a considerable accuracy error (TC 30-22, 1978, p. 27). The Soviet forces place great emphasis on the training of their radio direction finder personnel (Kidyayev, 1975, pp. 63-64). They are also very selective in choosing recruits to serve with radioelectronic combat units; only the most qualified are selected (Belov, 1973, pp. 2-4). For

these two reasons, the number of operator errors by radio direction finder personnel should be at a minimum.

Analysis of Intercepted Signals

The location of a transmitter by radio direction finder assets is only the first step in determining whether it will be destroyed or jammed. Soviet intelligence analysts must determine the type of target that has been located. This is accomplished by an analysis of the received signals.

The frequencies, rates of transmissions, number of messages, and type of transmitton, i.e. secure or nonsecure, are all factors that can identify the type of unit that has been located. This is especially significant considering the fact that the majority of U.S. communications doctrinal manuals are unclassified and widely distributed. Soviet study of U.S. and NATO doctrine and their equipments is clearly indicated by the large number of articles on those subjects in their magazine, Soviet Military Review (Belov, 1974, p. 12). A thorough study of U.S. tactics, current communications doctrine and equipment, and maps of possible combat areas enable the Soviet analysts to identify units from their electronic signals.

Although radio direction finding equipment cannot exactly locate transmitters and the command post they support, a careful study of the geographical terrain accompanied

by working knowledge of U.S. communications doctrine can reduce location errors drastically (Bowman, 1980, p. 5). A review of the Egyptian successes in locating Israel command posts by radio direction finding in the 1973 Middle-East War indicates that Soviet radio direction finder equipments when accompanied by trained analysts are extremely effective in a mid-intensity conflict (Brogdon, 1978, p. 31).

Sadly, most U.S. radiotelephone operators think the use of speech-security equipment provides them complete radioelectronic security. This is hardly the case. Speech-security equipment provides absolutely no protection from location by enemy radio direction finding equipments. It also enhances the enemy analyst's ability to identify command posts because only command and control nets use speech security equipment (TC 30-22, 1978, p. 28).

The combined use of radio direction finders and highly trained signal analysts provide the Soviets an effective combat multiplier that poses a significant threat to U.S. command and control communications. This capability to locate and identify U.S. command and control headquarters makes them vulnerable to both destruction by artillery fire power and a disruption of command and control communication through jamming. Figure 3-2 provides a pictorial display of the Soviet radioelectronic combat process.

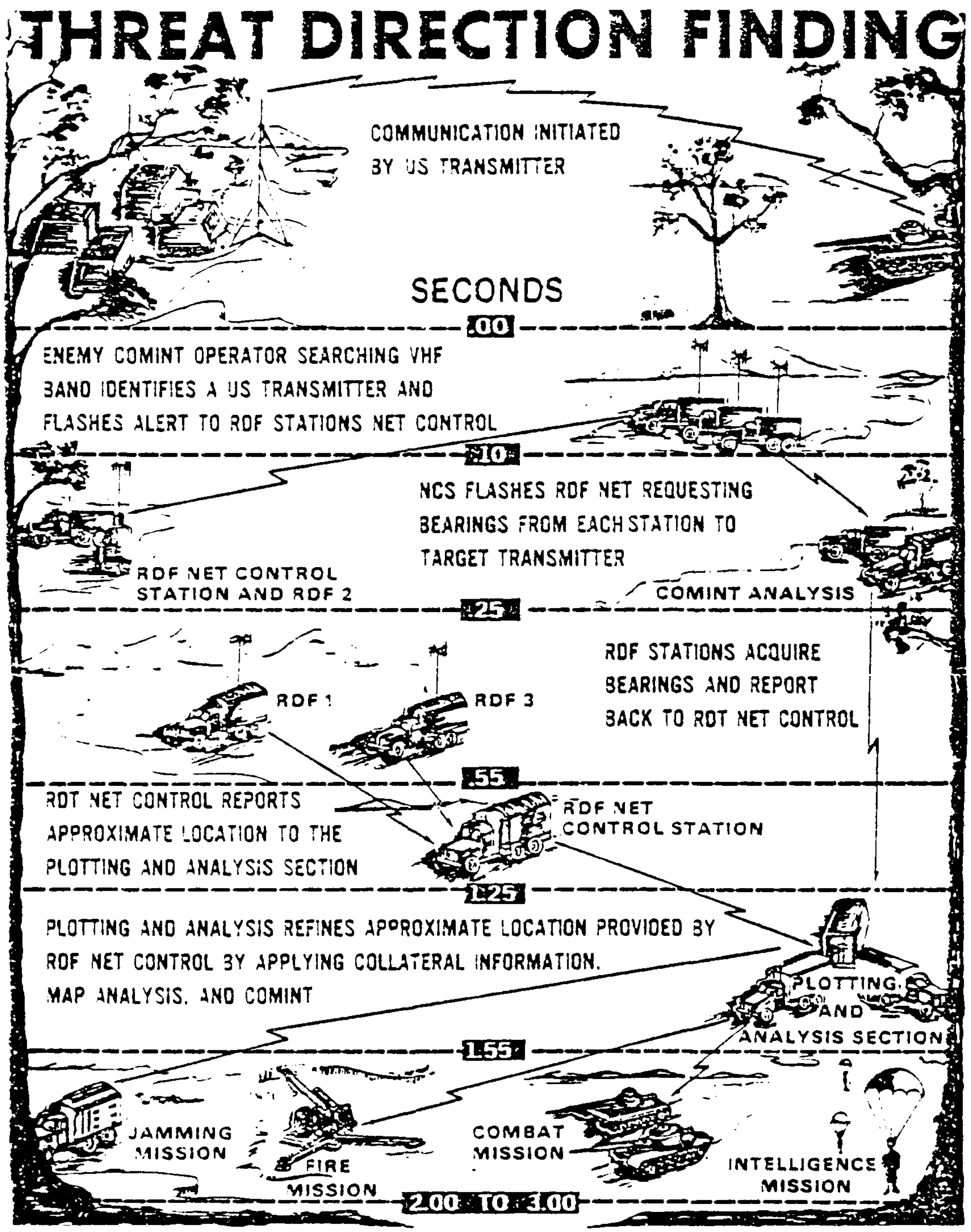


Figure 3-2 (Jayhawk, 1979, 13-IV-2)

Communications Jamming

The AIM division signal battalion provides communications assets normally located at distances between fifteen and forty kilometers from the forward edge of the battlefield. Soviet radioelectronic combat doctrine indicates all of the communications systems installed by the AIM division signal battalion are targets for either destruction or jamming because they are command and control systems. RB 100-33 states that:

> ...the largest single external threat to the continuance of U.S. communications is the enemy jammer. The enemy can be expected to jam low-level U.S. command, control communications nets across a broad spectrum. Many jammers will be used simultaneously, thereby disrupting command and control from division to squad level (RB 100-33, 1978, p. 2-6).

RB 100-33 provides the following definition for jamming: "Jamming is the deliberate radiation of energy to prevent or degrade the reception of information by a receiver" (1978, p. 1-7). Although this is the U.S. definition, it closely parallels the Soviet definition for active radio jamming, AKTIVNYYE RADIOPOMEKHI "...active radio jamming, affecting the enemy's radio receivers, disrupts completely or partially the reception and indication of useful signals ..." (Phrases, 1979, p. 42). The capabilities of the Soviet jammers have been thoroughly studied since the 1973 Middle-East War and the following conclusions are widely accepted. The Soviets have developed and deployed extensive high

powered jammers that have the capability to jam all the radio frequencies currently in use by U.S. units. Specifically, the high frequency, very high frequency, and ultra high frequency range radios have been identified and an adequate number of jammers have been produced to conduct massive jamming operations (RB 100-33, 1978, p. 2-7).

The Soviets have been able to identify high frequency signals and jam them since the early 1900's. The U.S. uses short distance high frequency transmitters as a means of backup for its multichannel system. Although these transmitters normally use ground wave propagation as the principal means of communication, they also produce an equal sky wave signal that can be intercepted by Soviet strategic radio direction finder equipments (TC 30-27, 1978, p. 16). Once located, high frequency stations are extremely vulnerable to jamming by Soviet high power strategic jamming stations and ground based high frequency jammers deployed with tactical forces (Bowman, 1980, p. 9). The high frequency signal's vulnerability to jamming was one of the reasons it was selected for elimination in the new family of communication systems provided by the integrated tactical communications system study (Renizi, 1976, pp. 24-25).

The Soviets have also developed and deployed a massive number of very high frequency jammers to counter

the U.S. reliance on frequency modulated, very high frequency tactical radios (Gordon, 1978, p. 46). Soviet jammers, although not as sophisticated by U.S. standards, are simple, rugged, and highly effective (Battlefield, 1979, p. 45). The technical characteristics of the Soviet very high frequency jammers will probably be as depicted in Table 3-1. Table 3-1 is compiled of information from Gordan, 1975, page 46, and Fiedler, 1979, page 34.

Soviet VHF Jammer

Mount:	Vehicular or Airborne
Power:	1500-2000 Watts
Frequency Range:	30-76 MHz
Antennas:	Several types of directional antennas
Method of Jamming:	Spot or barrage
Modes of Jamming:	Noise, gulls, tones, bagpipes, voices, pulses

Table 3-1

Numerous articles have been written recently discussing the tactical effectiveness of tactical jammers. Those authors, in the electronic warfare business, either within the military or commercial producers of electronic equipments, are quick to conclude that the enemy jamming threat is massive (Gordon, 1978, Slayton, 1980, and articles in Electronic Warfare magazine). Others (Bowman, 1980, Fiedler, 1979, and Follis, 1978) are not quite so convinced and present viable techniques to counter jamming effects or

to prevent jamming from being used. At best, the threat of tactical very high frequency jamming is a serious combat multiplier used extensively by the Soviets. Both Beaver, 1974 and Brogdon, 1979 pointed out the inadequacy of U.S. electronic counter-countermeasure training and its lack of effectiveness in tactical units.

The effectiveness of a communications jammer on a frequency modulated radio is determined by the power ratio between the jamming signal and the desired signal. This ratio is determined by the relative distances between the receiver and the two transmitters and their relative output powers. Battalion and brigade level nets are close to the forward edge of the battle area. Thus, they are exposed to greater jammer transmit power, but the distance between radios is much less than those encountered in the division level very high frequency nets. In other words, the greater distance from the forward edge of the battle area does not necessarily provide adequate protection from the jamming signal. Distance from the forward edge of the battle area does provide some protection from interception and radio direction finding, especially when directional antennas are used.

The effects of masking are significant on very high frequencies and provide some protection against ground based jammers, but provide very little protection against

airborne jammers. The Soviets use both ground based and airborne very high frequency jammers.

Soviet radioelectronic combat doctrine calls for intensive barrage jamming during a hasty or preplanned attack (Bowman, 1980, p. 5). This will deny large portions of the very high frequency spectrum from both friendly and enemy use. It also reduces the effective range of the jamming signal. For example, a two thousand watt jammer used to barrage jam twenty frequencies or very high frequency channels would result in a power reduction of the jamming signal to one hundred watts per channel. This greatly reduces its effective jamming range. Spot jamming of a single frequency has a much greater range but must be used against a previously identified frequency to be tactically effective. This requires the identification and location of U.S. command and control nets prior to initiating jamming efforts.

Soviet radioelectronic combat also uses ground based and airborne ultra high frequency jammers to jam U.S. multichannel communication systems (Bowman, 1980, p. 9). The greater distance from the forward edge of the battle area, low transmitter output, highly directional antenna, frequency range and type of modulation greatly reduces U.S. vulnerability to effective communications jamming. Only those systems that are installed on a perpendicular azimuth to the forward edge of the battle area are vulnerable to

jamming and even then the linear distance from the RDF to the transmitter is difficult to measure accurately (TC 30-22, 1978, p. 59). The use of the ultra high frequency range does make the identification of the command control communication systems much easier because of its type of signal. Also, the common practice of using very high frequency or high frequency radios with omnidirectional antennas to communicate with distant stations while installing ultra high frequency UHF systems, greatly increases vulnerability to radio direction or jamming. Jamming a highly directional ultra high frequency system is practically impossible from a ground based jammer when terrain masking techniques are used. Ultra high frequency systems are vulnerable from airborne jammers because they can achieve a line-of-site path at much greater distances. Current Soviet use of high powered, ultra high frequency, airborne jammers is limited but their increased use in the near future is expected (Bush, 1978, p. 64).

The ability of the Soviets and Warsaw Pact armies to jam essential U.S. command and control communications is a serious threat that must be considered in all phases of tactical planning. Although the Soviet radioelectronic combat soldiers are not ten feet tall, as some would have us believe, they are also not midgets. Their use of radioelectronic combat techniques on the modern battlefield is definitely an effective combat multiplier that must be

countered by active electronic counter-countermeasures. As Mr. O'Ballance deducted from the 1967 Middle-East War, the state of the art in electronics is a very dynamic condition. Any technical deficiencies current Soviet communications jamming assets posses will be rapidly and continually overcome.

Soviet Command and Control Communications

The Soviet and Warsaw Pact armies use a system of high frequency, very high frequency, and ultra high frequency radios to provide tactical command and control communications (RB 100-33, 1978, p. 2-4). These equipments are used in great quanities as in U.S. units. Although the radio design features are different, their frequency ranges and general use is very simular (Petukov, 1974, p. 5).

The Soviet primary means of tactical command and control is very high frequency radios with an almost identical frequency range as our AN/VRC-12 series of radios. High frequency radios, both voice and teletypewriter, with a simular frequency range as U.S. high frequency radios are also used to provide tactical communications (Petukhov, 1974, p. 8). The use of radios with simular frequency ranges limits the type of communications jamming conducted because they must avoid jamming their own signals. During a deliberate attack, it is expected the Soviets will use

radio listening silence while they are attempting to barrage jam U.S. communications (TC 30-22, 1978, p. 9).

The extensive use of the same frequency range presents an unintentional jamming signal to interfere with U.S. communications close to the forward edge of the battle area. It also requires the use of directional antennas to avoid jamming their own communication nets.

The Soviets also use highly directional, ultra high frequency radios for command and control at higher echelons. These nets are especially good for the transmissions of large volumes to command posts at the planning level (Petukhov, 1974, p. 8). These systems, although not as sophisticated as current U.S. systems, are similar in frequency range and general use as U.S. ultra high frequency systems (Battlefield, 1979, p. 45).

Current U.S. electronic warfare countermeasure techniques are targeted against the above Soviet communications systems. The additional use of the same frequency spectrum continues to crowd the electromagnetic environment and complicates the success of providing adequate communication. Neither the U.S. or the Soviet army can currently operate without extensive tactical communication means of multiple types. Although the Soviets may possess massive communications jamming capabilities, their use is curtailed

by the need of the Soviet army to maintain its own command and control.

SUMMARY

Soviet radioelectronic combat is the means the enemy intends to use to disrupt or destroy U.S. or allied command and control communications systems. The Soviets use radio direction finder equipment of all current tactical and strategic frequencies to locate and analyze intercepted radio signals. Once analyzed, they will make the decision to either destroy, jam, or intercept further communications from the located transmitter. If they decide to use communications jamming, they will task Soviet jammers to either spot or barrage jam the U.S. communications normally with high power noise signals.

The Soviets have built and deployed massive numbers of high frequency and very high frequency jammers. These jammers, although not as sophisticated as current U.S. communications equipment, are rugged, reliable and highly effective. They have the capacity to completely deny the use of high frequency communications systems and can severely impede the use of very high frequency systems if proper electronic counter-countermeasures are not employed by U.S. communicators. Although the Soviets do possess the capability to intercept ultra high frequency signals, the

difficulty in accurately locating a narrow beam ultra high frequency signal and then jam it, remains questionable.

The Soviets also utilize the same frequency ranges for their own command and control communications system making them equally vulnerable to U.S. electronic warfare efforts. This sharing of the same frequencies used for tactical communications also limits the communications jamming actions they may use because they are also dependent on communications to provide effective command and control in a combat environment.

CHAPTER IV

ANALYSIS

In this chapter the AIM division signal battalion's mission is analyzed against the Soviet communications jamming threat. This is accomplished by applying the concepts presented in Chapters II and III to the U.S. Army Command and General Staff College, Tactical Command and Control Exercise, P155, Blue Force Scenario. An AIM division multichannel system is deployed in accordance with the tactical scenario as of 292400 August. The vulnerabilities of the multichannel system, the high frequency radio teletypewriter and single sideband voice radio nets, and the frequency modulated voice radio nets to communications jamming are examined.

To analyze the effects of communications jamming, the following factors must be considered: the tactical situation, the number and location of jammers, the number and location of friendly transmitters, the terrain, weather, electronic warfare counter-countermeasure techniques utilized, and the capabilities of both commanders and soldiers. To accurately evaluate the total effect of that many variables, computerized wargaming techniques are required. The results of three computerized studies are provided in Annex A. Therefore, the scenario utilized for this

chapter provides the setting for a subjective discussion of U.S. communications jamming vulnerabilities. It is not an attempt to provide a manually wargamed analysis.

SCENARIO

The 54th Mechanized Infantry Division has the mission to delay enemy forces from line blue to the forward edge of the battle area for eight hours and then defend in sector. It has a division covering force mission and is augmented with two mechanized task forces from the corps covering force (Exercise, P155, inclosure B to Appendix 1). Each brigade has been further assigned a covering force sector as shown in Figure 4-1 (Exercise, P155, L1-AS-1-13).

The 54th Division is opposed by the U.S.S.R. and Warsaw Pact, 2nd Combined Arms Army consisting of the 9th Motorized Rifle Division, the 18th Motorized Rifle Division and the 2nd Tank Division. The enemy has employed radio direction finding and communications jamming against friendly forces. It is expected the 2nd Combined Arms Army will continue its attack and attempt to secure Rhine River crossing sites (Exercise P155, L1-AS-1-17 and 18).

This scenario represents current tactical doctrine of both U.S., Soviet, and Warsaw Pact forces as presented to the students of the U.S. Army Command and General Staff College class of 1980. The locations of the subordinate

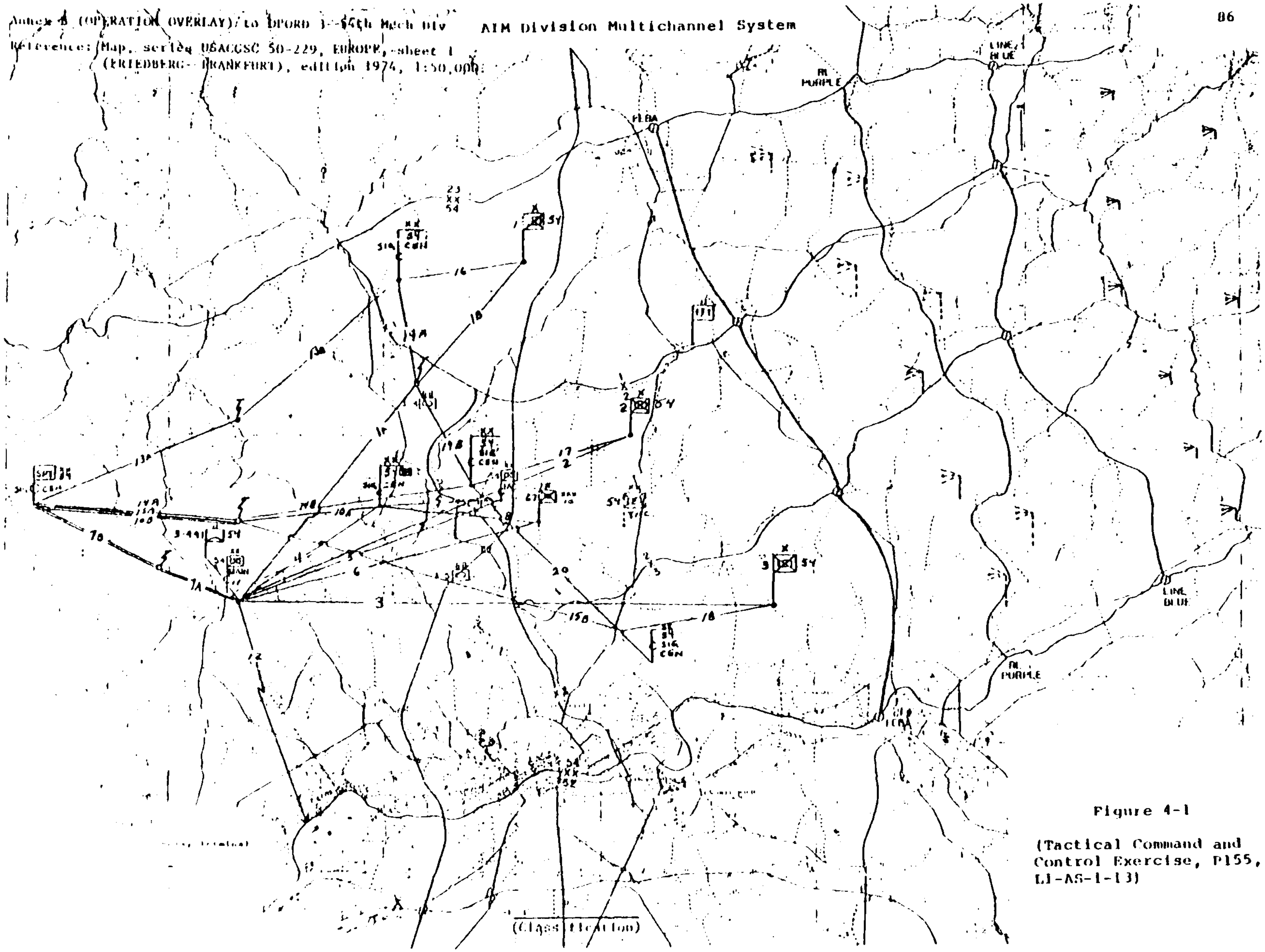


Figure 4-1

(Tactical Command and Control Exercise, P155, LI-AS-1-13)

AD-A094 435 ARMY COMMAND AND GENERAL STAFF COLL FORT LEAVENWORTH KS F/G 17/4
THE EFFECTS OF SOVIET ARMY COMMUNICATIONS JAMMING ON THE AIM DI--ETC(U)
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brigade command posts, the air defense artillery battalion headquarters, the division support command headquarters, and the engineer battalion headquarters were determined by appropriate branch qualified student controllers. The locations for the remaining units were identified by the scenario for Phase III, time sequence 292400 August (Exercise, P155, Inclosure B to Appendix 1).

Multichannel System

The 54th Signal Battalion multichannel system is configured to support the division as shown in Figure 4-1. The communications system represents the doctrinal multichannel system as explained in Chapter II of this thesis. Radio systems are not required to support the division rear elements and the division airfield because they are collocated with the division support command and the division main command post, respectively.

The engineer battalion is supporting the covering force mission at the beginning of the scenario. The headquarters is located forward of the brigade command posts along the forward edge of the battle area. Frequent relocation is currently required making it impossible to support it with a multichannel system. The installation of a multichannel system to the engineer battalion headquarters would normally be accomplished when the covering force mission is completed.

The division multichannel system, as shown in Figure 4-1, requires the installation of twenty multichannel radio systems. Seven of them require the installation of radio relay terminals to achieve a line-of-site path. This was determined by conducting a map analysis of the terrain between the locations being supported. Additional radio relays could be required in an actual situation. Prior to deployment, a thorough ground and aerial reconnaissance would be conducted to insure the availability of adequate line-of-site paths. The radio systems comprising the multichannel communications system are listed in Table 4-1.

The criteria for determining the multichannel system's vulnerability to jamming, as explained in Chapters II and III, is as follows: distance to enemy jammer locations, availability of terrain features that provide masking, and the azimuths of multichannel systems relative to possible enemy jammer locations. The AN/GRC-103 radio system's antennas use both vertical and horizontal polarization, therefore antenna polarization is not considered an evaluation factor. The assignment of frequencies for each system is accomplished during installation. They are normally not changed until a system is relocated. This differs from frequency assignment procedures used for AN/GRC-106 and AN/VRC-12 series radios where frequency

Division Multichannel System

System Number	Location		
1A & 1B	Div Main CP	to	1st Bde CP
2	Div Main CP	to	2nd Bde CP
3	Div Main CP	to	3rd Bde CP
4	Div Main CP	to	Div Arty Sig Cen
5	Div Main CP	to	Div TAC CP
6	Div Main CP	to	67th Artillery Bde
7A & 7B	Div Main CP	to	Div Spt Cmd
8	Div Arty Sig Cen	to	67th Artillery Bde
9	Div Arty Sig Cen	to	Div TAC CP
10A & 10B	Div Arty Sig Cen	to	Div Spt Cmd
11	Div Main CP	to	ADA Bn CP
12	Div Main CP	to	Adjacent Div
13A & 13B	Div Spt Cmd	to	1st Bde FASC
14A & 14B	Div Spt Cmd	to	2nd Bde FASC
15A & 15B	Div Spt Cmd	to	3rd Bde FASC
16	1st Bde FASC	to	1st Bde CP
17	2nd Bde FASC	to	2nd Bde CP
18	3rd Bde FASC	to	3rd Bde CP
19A & 19B	1st Bde FASC	to	2nd Bde FASC
20	2nd Bde FASC	to	3rd Bde FASC

TABLE 4-1

changes are made periodically to provide a measure of electronic warfare protection. The availability of frequencies in the ultra high frequency range is extremely limited because of many other military and civilian uses of this frequency range. Also, the multichannel system's complexity and requirement for continuous service has prevented the use of frequency changes as an electronic counter-countermeasure technique for that system.

In the 54th Mechanized Infantry Division's multichannel system, the radio terminals are located from six

to forty kilometers from the forward edge of the battle area. Initially the line of contact, line blue, is some distance from the forward edge of the battle area. As the delay action progresses, the line of contact will approach the forward edge of the battle area enabling enemy communication jammers and radio direction finders to come within approximately ten kilometers of brigade command posts.

The brigade command posts are located on the westward slope of high ground which enables them to use terrain masking to protect their westward directed radio systems. But, the terrain in this region does not provide adequate terrain masking to completely block the eastward transmission of multichannel systems 2, 3, 16, 17, and 18 across the forward edge of the battle area. These five systems are on perpendicular azimuths to the forward edge of the battle area.

Systems 16, 17 and 18 are vulnerable to ground based jammers because their forward area signal center terminals are approximately fifteen kilometers from locations that will become available to the enemy as the delay action progresses. The terrain surrounding these systems does not provide adequate masking to prevent their interception. As explained earlier, it is extremely difficult to accurately locate this type of narrow beam radio signal.

Therefore, communications jamming, rather than destructive fires, would be targeted against the forward area signal center terminals of these three systems, making them unreliable.

Systems 2 and 3 are not as vulnerable to ground based jamming as systems 16, 17 and 18 because their division main command post terminals are located approximately thirty-five kilometers from locations available to enemy communications jammers and radio direction finders. This distance plus the terrain surrounding the division main command post make it improbable that ground based jammers could successfully interfere with these two systems. The use of airborne jammers and radio direction finders eliminates any protection provided by this distance and makes the two systems vulnerable to communications jamming. As stated in Chapter III, the Soviets have airborne jamming platforms and are increasing their manufacture and deployment.

Systems 1A, 1B and 13B have an azimuth that crosses the forward edge of the battle area in the 23rd Armored Division sector. The vulnerability of these systems is questionable. Their transmission path azimuths are approximately forty-five degrees in relation to the forward edge of the battle area. The distance the signals must travel before they penetrate areas available to enemy

jammers and radio direction finders is approximately fifty-five kilometers. A map analysis of this terrain also indicates adequate terrain masking to protect systems 1A, 1B and 13B. Therefore, these systems are not considered vulnerable to jamming.

Systems 7A, 7B, 10B, 13A, 14A and 15A all have azimuths that would eventually cross the forward edge of the battle area in the 54th Division sector. In each case adequate hill masses are provided by the terrain to mask their signals from enemy interception and jamming. Therefore, these systems are not considered to be vulnerable to enemy radioelectronic combat efforts.

Systems 4, 5, 6, 8, 9, 10A, 14B and 15B all have azimuths roughly perpendicular to the forward edge of the battle area. After carefully conducting a map analysis of their extended azimuths into the enemy sector, the availability of terrain features to mask their signals appears to be inadequate. These systems are approximately 15 to 30 kilometers from locations that will become available to enemy direction finders and jammers. They are considered to be vulnerable to enemy communications jamming.

Of the twenty systems comprising the 54th Division's multichannel communication system, thirteen are considered to be theoretically vulnerable to enemy interception and communications jamming. A system that requires a relay

terminal is considered vulnerable if either portion of the system is vulnerable. For example, system 14A was not vulnerable to jamming because it was masked by a high hill mass, but system 14B was not protected from enemy jamming and interception. Therefore, the entire system, 14A and 14B, was considered vulnerable to interception and jamming because the interruption of one portion of the relayed system will result in the entire system being disrupted.

This evaluation resulted in determining that sixty-five percent of the systems in the 54th Division's multi-channel communications system were theoretically vulnerable to enemy jamming. The actual vulnerability of this system also would depend on the enemy's use of their electronic warfare radioelectronic combat assets. Since definitive information concerning Soviet radioelectronic combat is classified, the assumption that the enemy has the capability to take advantage of the theoretical weaknesses in the U.S. communication system has been made. This is commensurate with information that was presented and referenced in chapter III.

In addition, the thirteen systems that are vulnerable to interception and jamming are terminated at the major command posts in the division. The identification of a command post and its subsequent targeting for

destructive fires will further degrade the division's multichannel system. The interception of an ultra high frequency directional signal does not provide, by itself, enough information for accurate targeting but, coupled with additional intelligence, it greatly assists in the identification of command posts and their locations.

Radio Equipment and Locations

3 Brigade CP's	3 Forward Area Signal Centers	Div Tac CP
(2ea) AN/GRC-103	(4ea) AN/GRC-103	2 AN/GRC-103
(2ea) AN/GRC-106	(1ea) AN/GRC-106	3 AN/GRC-106
* AN/VRC-12	(3ea) AN/VRC-12	2 AN/VRC-12
Div Main CP	**Div Spt Cmd**	**Div Arty Sig Cen**
14 AN/GRC-103	8 AN/GRC-103	8 AN/GRC-103
3 AN/GRC-106	2 AN/GRC-106	3 AN/VRC-12
3 AN/VRC-12	1 AN/VRC-12	* AN/GRC-106
Corps Artillery Bde	**ADA Bn**	**Engineer Bn**
2 AN/GRC-103	2 AN/GRC-103	* AN/GRC-106
* AN/GRC-106	* AN/GRC-106	* AN/VRC-12
* AN/VRC-12	* AN/VRC-12	

* indicates radios belonging to units other than AIM division signal battalion.

TABLE 4-2

Single Channel Radios

The high frequency and very high frequency radio systems of the 54th Signal Battalion are shown in table 4-2. The location, quantity, and ownership of each radio may be identified by comparing table 4-2 and figure 4-1. Both will

be used as references for the discussion of vulnerabilities to communications jamming.

The criteria for determining the above radio systems' vulnerability to jamming, as explained in Chapters II and III, is as follows: distance to enemy jammer locations, availability of terrain features that provide masking, and type of radio propagation path.

The AN/GRC-106 and AN/VRC-12 series radios located at the brigade command posts and the engineer battalion headquarters are extremely close to the forward edge of the battle area. As the scenario progresses, they will be within ten kilometers of positions available to enemy radio direction finders and jammers. The vulnerability of their AN/VRC-12 series radios is extremely high as indicated by the computations in Figure 4-2.

ECCM TECHNIQUES AFFECTING AN/VRC 12 RADIO

(RADIO IS 10 kms FROM ENEMY GROUND INTERCEPT/DF SYSTEM)

SITUATION	TRANSMIT POWER	FREQUENCY	APPROXIMATE ANTENNA HEIGHT	ANTENNA POLARITY	PROBABILITY OF INTERCEPT	PROBABILITY OF DIRECTION FINDING EXPRESSED AS CEP *
BASE SITUATION	HIGH POWER 35 WATTS	47 MHz	3 METER AT 912 OR AS 1729	VERTICAL OMNIDIRECTIONAL	99%	750 METERS
1	35 WATTS	47 MHz	10 METER RC 292	VERTICAL OMNIDIRECTIONAL	99%	500 TO 750 METERS
2	LOW POWER 8 WATTS	47 MHz	3 METER AT 912 OR AS 1729	VERTICAL OMNIDIRECTIONAL	83%	750 METERS
3	LOW POWER OR HIGH POWER	47 MHz	3 METER AT 904/A/G LONG WIRE OR FIELD EXPEDIENT	HORIZONTAL DIRECTIONAL	15%	DF SYSTEM CANNOT TAKE BEARINGS ON THIS SIGNAL 85% OF TIME

FRIENDLY DATA [illegible]

ENEMY DATA [illegible]

Figure 4-2 (Jayhawk, 1979, L3-IV-1)

There are no terrain features in their areas of operation that can adequately provide masking protection for the AN/VRC-12 series radio nets. The use of horizonitally polorized, directional artennas could provide some protection, as indicated in Figure 4-2, but the rapidly changing tactical situation and the requirement to communicate over a wide area of operations preclude their use.

The AN/GRC-106 radios at these locations provide command and control communications. The radios use the ground wave propagation path to accomplish this mission but, at the same time, emit a sky wave propagation path signal. This sky wave signal makes them vulnerable to radio direction finders located in rear areas. Other stations in the nets, of which these radios are a part, must communicate forward to the brigade headquarters and engineer battalion headquarters locations. This makes the net frequency vulnerable to interception. Since high powered ground based jammers are capable of jamming up to approximately eighty kilometers with a ground wave signal, the reliability of the entire net becomes extremely questionable. This indicates a probable breakdown of the division operations net (RATT) and the division intelligence net (RATT) as depicted on pages 40 and 41 of this thesis.

The AN/GRC-106 and AN/VRC-12 series radios located at the three forward area signal centers are approximately twenty kilometers from locations available to enemy radio-electronic combat assets. The AN/VRC-12 series radios are primarily used to provide radio wire integration and re-transmission terminals. These terminals are provided adequate terrain masking by hill masses between themselves and enemy locations and are not considered vulnerable to interception and jamming.

The AN/GRC-106 radio is provided at the forward area signal center for operation in the division administrative and logistics net. Ground wave propagation is used to accomplish this mission but, as explained earlier, a sky wave signal is also produced. This makes the net vulnerable to interception. Additionally, the division administrative and logistics net terminals are widely dispersed, Figures 4-1 and 2-9, making the net frequency vulnerable to interception. All stations in the net are located within range of high powered ground based enemy jammers. This makes the net extremely vulnerable to enemy jamming.

The AN/GRC-106 and AN/VRC-12 series radios at the division tactical command post are located approximately twenty kilometers from possible enemy jammer locations. The AN/VRC-12 series radios belonging to the signal

battalion are provided adequate terrain masking to accomplish their mission of providing a radio wire integration terminal without being vulnerable to enemy jamming.

The AN/GRC-106 radios operate in the division operations net (RATT), the division intelligence net (RATT), and the division tactical operations net (SSB) (Figures 2-10, 2-11, 2-12). These radios emit both ground wave and sky wave signals making their interception very probable. The other stations in the three nets are widely dispersed, thus, the vulnerability of these nets to enemy jamming is extremely high.

The AN/GRC-106 and AN/VRC-12 series radios located at the division main command post, the division artillery signal center, and the division support command have the same vulnerabilities as previously discussed. The AN/VRC-12 series radios of the signal battalion are protected by terrain masking and are not considered vulnerable to jamming. The AN/GRC-106 radios and the nets in which they operate are vulnerable to interception and jamming using the same criteria as previously explained.

The AN/GRC-106 and AN/VRC-12 series radios belonging to units other than the signal battalion, Figure 4-1, have the same vulnerabilities previously considered. The AN/GRC-106 radios are going to be extremely vulnerable to

interception and jamming due to sky wave emissions and proximity to the enemy ground based jammers.

The AN/VRC-12 series radios in the division intelligence net (FM) and the division command/operations net (FM), Figures 2-7 and 2-8, are much more vulnerable than the AN/VRC-12 series radios operated by the signal battalion. The stations in these two nets are widely dispersed throughout the division area. This requires a net design that is able to communicate over a broad area. Thus, the effective use of masking terrain to provide protection from interception and jamming is limited. Also, these two nets must communicate with stations in proximity to the forward edge of the battle area. To do this, high power outputs and omnidirectional antennas are required because other stations are located in the division rear, i.e. the division support command. The vulnerability of these two nets must be considered extremely high.

Some analysts would argue that speech security devices and frequent frequency changes in AN/VRC-12 series radio nets provide them a degree of protection from interception and jamming. TRADOC's Combat Communications Systems Study, 1977, pages II-4 and II-5, shows that the security provided by frequency changes decreases very rapidly after the first eight hours of net operation. Speech security devices provide protection against

intelligence gathering when a net frequency is intercepted but do not hide either the transmitted frequency or the transmitting station's location. Therefore, the use of speech security devices was not considered a factor in reducing these nets vulnerability to interception and jamming. In fact, the identification of a speech security device identifies the net as one that is being used for command and control.

The AN/GRC-106 and AN/VRC-12 series radios belonging to other divisional units are, in many cases, collocated with the radio assets belonging to the signal battalion. Their vulnerabilities to interception and jamming increase the signal battalion's vulnerability to the same threat. For example, the signal battalion operates the radio assets shown in Table 4-2 at the division main command post. Numerous additional AN/GRC-106 and AN/VRC-12 series radios are operated at the division main command post by division headquarters elements and other collocated unit headquarters. This concentration of radio signals at one location greatly increases the enemy's capability to intercept and identify the division main command post communications. Thus, the vulnerability of all the communication systems at the one location is greatly increased. This is also true of the signal battalion's communications assets at each supported location.

SUMMARY

The 54th Signal Battalion's communication systems in this example provide the enemy with many opportunities to completely disrupt the division's command and control. The multichannel system has sixty-five percent of its systems vulnerable to interception and jamming. The high frequency systems using the AN/GRC-106 radio are one hundred percent vulnerable to interception and jamming. Although many of the signal battalion's AN/VRC-12 series radio nets were found not to be vulnerable to interception and jamming, numerous nets operated by collocated units were considered extremely vulnerable.

In this subjective analysis, all the locations of the signal battalion radio terminals could be intercepted, identified, and targeted by either distructive fires or enemy jammers. The terrain used for the analysis is considered typical of operational areas in Europe. Adequate hill masses, forests and builtup areas are available to provide some masking protection for isolated systems. But, because of the numerous collocated radio terminals, the locations of all the signal battalion assets were considered vulnerable to enemy radioelectronic combat efforts.

CHAPTER V

A FINAL REVIEW

In this chapter, a summary of the findings and conclusions of this thesis is presented. The shortcomings of the study, as perceived by its author, are discussed. Recommendations to improve the survivability of division level communications systems and the subsequent success of the division commander and his subordinate signal battalion commander are explained.

The main objective of this thesis was to show that current division signal battalion communication systems would not provide satisfactory support when confronted by Soviet radioelectronic combat efforts. This has been accomplished in Chapter IV and Annex A of this paper. Therefore, the thesis hypothesis that Soviet Army's communications jamming capabilities will severely interfere with and impede the mission accomplishment of the AIM division signal battalion has been proven.

A second objective of this thesis was to identify the difficulties and complexities of the signal mission in an electronic warfare environment so that the division commander and his staff will not mistakingly assume that reliable communications can be provided under present

threat conditions. This has been accomplished by providing a detailed explanation of the division signal battalion's capabilities in Chapter II and the Soviet Army's communications jamming capabilities in Chapter III and Annex A.

Findings and Conclusions

The vulnerability of the AIM division's communication systems to the Soviet radioelectronic combat threat is a result of a combination of factors. The Soviets continued to develop their electronic warfare capabilities after World War II while the U.S. Army was content to maintain an almost status quo electronic warfare capability. The electronic battlefield encountered by both sides in the Arab and Israeli 1973 Middle East War caused the U.S. Army to reexamine the use of electronic warfare techniques as a combat multiplier. This resulted in an increased emphasis on both offensive and defensive electronic warfare techniques (Gordon, 1980, p. 3).

This period of electronic warfare equipment development inactivity caused a gap between Soviet and U.S. forces electronic warfare capabilities and U.S. communication systems became increasingly vulnerable to the Soviet radioelectronic combat threat. The U.S. Army Development and Readiness Command began an electronic warfare equipment development catch up effort in 1974

(Meyer, 1974, p. 28). This effort includes both offensive electronic warfare equipment and communication equipment with better defenses against the Soviet radioelectronic combat threat. The new communication equipment will begin being fielded in approximately 1985. Although they will provide greater electronic warfare protection in the future, the current family of division level communications equipment remain seriously vulnerable to the Soviet radioelectronic combat threat.

Current electronic counter-countermeasure techniques provide only a limited measure of protection against Soviet intercept and communications jamming. The use of terrain features to mask friendly line-of-site signals from enemy radio direction finders and jammers works very well when radio terminal locations can be carefully selected. This is not always possible because the units supported by the AIM division signal battalion must select sites for their headquarters and command posts commensurate with the division's tactical situation and operations plans. The division commander is required to develop the most feasible tactical plan possible. In doing so, he must weigh the various risks involved with each of the possible courses of action. As was shown in Chapter IV, the division commander's concept of the operation, while being the best tactically, may result

in exposing the majority of his communication systems to Soviet interception and communications jamming.

The use of highly directional antennas in the division's very high frequency, frequency modulated, radio nets is subject to the same type of tactical risk versus elctronic warfare protection situation. Current division very high frequency, frequency modulated, radio nets are comprised of many widely dispersed terminals. In order to establish communications, high power radio settings and omnidirectional antennas are required. This makes the net very vulnerable to enemy intercept and jamming.

Current high frequency voice and radioteletypewriter radios are extremely vulnerable to interception and jamming because they emit sky wave signals. There is very little that can be done to reduce their vulnerability as long as the current family of high frequency radios are used. The introduction of burst transmission devices, such as those used with the AN/PRC-74, and appropriate radio telephone operator electronic warfare counter-countermeasure techniques may be utilized to reduce transmission lengths. This could reduce the high frequency radio system's vulnerability in the future but is no help to the present situation.

The AIM division signal battalion communication system's vulnerability to enemy interception, radio

direction finders, and communications jamming is greatly exacerbated by the radios and other electronic emitters belonging to the units it supports. The increased electronic signature of these collocated emitters makes it easier for the enemy to intercept, locate, and identify the supported unit. This makes both the supported unit and the signal battalion's assets more vulnerable to communications jamming.

The combined threat of interception, locationing, communications jamming, and destruction by enemy firepower places the AIM signal battalion commander in a seriously vulnerable position. Under present threat circumstances it is very improbable that he can continually provide the required communications support to the division. The division commander cannot be assured he can maintain an effective command and control system during the battle. Both the division commander and his subordinate signal battalion commander share the responsibility for sustaining the division signal battalion's communication systems in an electronic warfare environment. Command post site selections must be accomplished commensurate with both the tactical situation and the need to provide as much protection from the Soviet radioelectronic combat threat as possible. Without such consideration, neither the

division commander nor his signal battalion commander can hope to accomplish their mission and win on the electronic battlefield.

Shortcomings

In the process of researching both published and unpublished material for writing this thesis, a number of shortcomings in available studies were discovered. Since these shortcomings have an effect on the validity of this thesis, they are discussed so that the reader may draw his own conclusions.

The computerized study conducted by the U.S. Army Signal School failed to wargame the vulnerability of single channel, very high frequency, frequency modulated radios because the student authors felt they would be ineffective in the current electronic warfare environment. Although previous studies concluded that these radios were technically vulnerable to interception and communications jamming, the conclusion that these radios would be tactically ineffective seems to be unfounded.

The same study uses a series of critical time periods or incidents as a basis to calculate losses of communications equipment. The study did not explain how these losses were calculated, the method of destruction used, or how the controllers made their conclusion. This

study was the only one available that addressed the problem of continued command and control communications. Its results were not out of line with other studies that addressed the Soviet radioelectronic combat threat. For that reason, the conclusions made by the study were accepted for use in this thesis. Further studies, concerning the tactical effectiveness of Soviet radioelectronic combat, will be required to determine if the assumptions made by the students at the U.S. Army Signal School are valid.

The majority of studies used for references by this thesis addressed the technical vulnerability of U.S. communications equipment to the effects of Soviet radioelectronic combat. It must be stressed that technical vulnerability does not equal tactical vulnerability. None of the studies currently available attempted to determine the tactical effectiveness of Soviet radioelectronic combat. This can only be accomplished on the battlefield.

The use of Soviet authored documents as references requires that both the author and his readers recognize that these documents must be evaluated critically. The Soviets are known for overstating their strengths and understating their weaknesses. After reading numerous Soviet articles published in English, a reader could conclude that the Soviet's possess an unbeatable combat force. It must

be recognized that this is the impression intended by the Soviet publisher. The validity of what has been published must be considered suspect. These articles are extremely valuable when attempting to understand the Soviet military mind and Soviet military planners logic.

Recommendations

In order for the AIM division to overcome the effects of the Soviet radioelectronic combat threat the combined efforts of the signal battalion commander, the combat electronic warfare and intelligence battalion commander, and the division maneuver commanders are required. Currently the signal battalion commander is concerned about defensive electronic counter-countermeasure techniques to reduce his vulnerability to Soviet radioelectronic combat. The combat electronic warfare and intelligence battalion's efforts are primarily electronic countermeasure techniques and intelligence gathering. While the maneuver commanders are relying too heavily on electronic communications to maintain command and control on the battlefield.

Until new communications equipment is fielded that can reduce the division's vulnerability to Soviet radioelectronic combat efforts, a combined effort must be used to counter the threat. The signal battalion and the combat electronic warfare and intelligence battalion must either

establish a joint operations center or effective liaison channels. In other words, both the offensive and defensive efforts must be combined.

The use of electronic countermeasure techniques to provide protection for the division's communication systems must be accomplished. The use of available electronic countermeasure equipment to ram through essential communications must be not only considered but be a planned and practiced procedure. The planning of division communication systems must be accomplished to provide maximum reliability. This means that both the planners from the division operations section and the combat electronic warfare battalion must become actively involved with the signal battalion planning staff.

The reliance on electronic communications to provide command and control must be reduced whenever possible. This can be best accomplished through well prepared and practiced operation plans. Division manuever elements must be able to continue to execute a well organized and tactical effective operation in the absence of electronic communications. Until this is accomplished, the AIM division will remain unnecessarily vulnerable to the Soviet radioelectronic combat threat.

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